SNAME PANEL SP-3
Surface Preparation and Coatings
REPRINT

U.S. DEPARTMENT OF TRANSPORTATION
Maritime Administration

in cooperation with

National Steel and Shipbuilding Company
San Diego, California

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **MAY 1980**	2. REPORT TYPE	3. DATES COVERED **00-00-1980 to 00-00-1980**
4. TITLE AND SUBTITLE **SNAME Panel SP-3 Surfacce Preparation and Coatings. Reprint**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD,Code 2230 -Design Integration Tower,9500 MacArthur Blvd Bldg 192 Room 128,Bethesda,MD,20817-5700**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**105**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

TABLE OF CONTENTS

FOREWORD

This research project was performed under the National Shipbuilding Research Program. The project, as part of this program, is a cooperative cost shared effort between the Maritime Administration, Avondale Shipyards, Inc. and Offshore Power Systems, a wholly owned Westinghouse subsidiary. The overall objective of the program is improved productivity and, therefore, reduced shipbuilding costs to meet the lower Construction Differential Subsidy rate goals of the Merchant Marine Act of 1970.

The studies have been undertaken with this goal in mind, and have followed closely the project outline approved by the Society of Naval Architects and Marine Engineers' (SNAME) Ship Production Committee. The research effort for the project was assigned, by subcontract, to Offshore Power Systems.

Mr. Benjamin S. Fultz, of Offshore Power Systems, served as Project Manager. Mr. Job Travassos, of the same company, performed all testing operations. On behalf of Avondale Shipyards, Inc., Mr. John Peart was the R & D Project Manager responsible for technical direction, editing and publication of the final report. Program definition and guidance was provided by the members of the 023-1 Surface Preparation Coatings Committee of SNAME, Mr. C. J. Starkenburg, Avondale Shipyards, Inc., Chairman.

Special thanks are given to Dr. Daniel R. Uhr, Jr. of Pfizer Chemicals Division for suppling technical direction on citric acid cleaning solutions and processes. Also, thanks are extended to Mr. William Arbiter and Mr. Steve Hollwarth who reviewed the draft of this report and offered valuable criticism. Also we wish to acknowledge the support of Mr. Jack Garvey and Mr. Robert Schaffran, of the Maritime Administration, and the contributions of the following corporations:

Ameron Corrosion Control Division, Beria, California
Avondale Shipyards, Inc., New Orleans, Louisiana
Bywater Sales and Service Co., Inc., Belle Chase, Louisiana
Carboline Marine Corporation, St. Louis, Missouri
Devoe and Raynolds Company, Louisville, Kentucky
Farboil Company, Baltimore, Maryland
Imperial Coatings Corporation, New Orleans, Louisiana
International Paint Company, Inc. New York, New York
Mobil Chemical Company, Edison, New Jersey
Mobile Paint Manufacturing Company, Mobile, Alabama

NAPKO Corporation, Houston, Texas

Offshore Power Systems, Jacksonville, Florida

Pfizer Inc., Chemicals Division, Groton, Connecticut

Porter Coatings, Louisville Kentucky

Sigma Coatings, Harvey, Louisiana

EXECUTIVE SUMMARY

In the present climate of increased federal and local regulations on alleged pollution producing manufacturing operations, open abrasive blasting is being scrutinized for possible further regulation. Outright prohibition may be the final outcome.

First indications are that citric acid cleaning processes offer a partial solution to the pollution problem. These cleaning processes are potentially nontoxic and biodegradeable. Spent solutions can easily be disposed of by treatment in a boiler or other incineration device.

Another advantage of citric acid is the relative nonaggressiveness of the acid to the base metal. The oxides (rust) are removed with little or no effect on the underlying steel.

Realizing the potential merits of citric acid cleaning, the 023-1 panel of SNAME developed a proposed research and development project to investigate the suitability and acceptability of citric acid cleaning processes in new ship construction.

The first step of any proposed new surface preparation must be to determine the compatibility of present state-of-the-art coating systems with surfaces cleaned via the proposed cleaning process. This project, "Cleaning of Steel Assemblies and Shipboard Touch-up Using Citric Acid (Phase I)", accomplished the above stated goal.

Based on the testing results contained within this report, in most cases, coating systems applied over citric acid cleaned steel performed as well as or superior to the same coating system applied over abrasive blasted steel. Stated another way, most coating systems appear to be compatible with citric acid cleaned substrates.

Based on the success achieved in Phase I, a Phase II project is now warranted to further investigate the merits of citric acid. Points which need further investigation are:

- Availability/Producibility of Production Cleaning Equipment
- Economic Considerations and Tradeoffs
- Precise Environmental Impacts

LIST OF FIGURES

LIST OF TABLES

SECTION 1
CONCLUSIONS

1. CONCLUSIONS

1.1 Project Results

As stated in the executive summary, the goal of this project was the determination of capability between state-of-the-art marine coatings and citric acid cleaned steel. To test compatibility within a reasonable time period, four test environments were selected which would provide representative performance data under marine exposure conditions. These environments are as follows:

- Salt Spray (Fog) for 2500 Hours - Marine Exterior Exposed to Weather
- Aged Adhesion - All Marine Applications Other Than Underwater
- Exterior Test Fence - Interior and Exterior Marine Primers
- Hydrostatic Test Tank - Tank Coatings and Some Immersion Resistance

The results and conclusions of these tests are summarized below:

1. Coating systems applied over citric acid cleaned steel performed as well as or superior to the same system applied over abrasive blast cleaned steel when exposed in a salt spray test chamber for 2500 hours (See Table I).
2. All epoxy coating systems tested for aged adhesion over citric acid prepared surfaces demonstrated equal or superior adhesion properties to the same system applied over abrasive blast prepared surfaces. (See Tables II and III).
3. Some inorganic zinc coating systems tested for aged adhesion over citric acid prepared surfaces demonstrated equal adhesion properties to the same system applied over abrasive blast prepared surfaces. Some systems demonstrated inferior adhesion properties (See Tables II and III).
4. The inorganic zinc primers demonstrating inferior adhesion properties in number 3 above, performed satisfactorily when tested in the salt spray and on the exterior test fence.
5. All generic primers applied to citric acid cleaned surfaces equaled or outperformed the same generic primers applied to abrasive blast cleaned surfaces and similarly exposed on a test fence with a 45° South exposure in a marine environment.
6. Citric acid touch-up cleaning must be supplemented by mechanical cleaning techniques when cleaning and preparing weld damaged areas.

7. Tank coating systems applied over citric acid cleaned steel performed as well as or superior to the same tank coating system applied over abrasive blast cleaned steel when tested in a hydrostatic tank filled with synthetic seawater. (See Table VI).
8. In most cases, tank coating systems applied over citric acid cleaned steel performed as well as the same tank coating system applied over abrasive blast cleaned steel when tested in a hydrostatic tank filled with deionized water. Two of fourteen systems tested demonstrated inferior performance. (See Table VII).

In summary, most of the tested coatings (paint) demonstrated capability with citric acid cleaned surfaces. However, this does not mean that all coatings can be successfully applied over citric acid prepared steel. Each coating system under consideration should be specifically tested for performance according to defined service conditions.

1.2 Cost Savings

Exact cost savings are difficult to define at this time. The principle attraction rests on the fact that abrasive blasting may be restricted and another process must be used. Cost savings may be realized considering that spent abrasive blast media must be collected and disposed of. Whereas acid solutions have the potential of economic disposal by utilizing their biodegradability or by virtue of their ready incineration or regeneration.

1.3 Continued Research and Development

As a result of the success of this study, a Phase II project is now justified to identify or design processes and/or equipment to adapt citric acid cleaning to shipyard methodology. Processes and equipment must be economical and environmentally acceptable.

The sequence of Phase II should be such that the first step is the investigation of the exact environmental impact of citric acid cleaning. Even though cursory information to date tends to support environmental acceptability, federal and state agencies must be queried as to their exact position on the use of citric acid and passivator solutions. The end result of this step or subproject would be an environmental impact statement to include a definition or level of hazard.

The second part of the study should be an economic evaluation of

SECTION 2
PROJECT PLAN OF ACTIONS AND RESULTS

2. PROJECT PLAN OF ACTIONS AND RESULTS

2.1 Background Technical Information

Iron, having a chemical valence of +2, +3, +4 or +6 can readily react with atmospheric oxygen to form many different oxides and hydrates. Those actually formed depend on conditions of temperature, moisture, contamination and availability of oxygen. These oxides, generally called corrosion or rust, can vary from the normally seen atmospheric ferric hematite (Fe_2O_3) to tenacious magnetite (Fe_3O_4).

Rust must be removed prior to paint application to assure successful paint performance. Corrosion products can be removed either mechanically or chemically. The mechanical approach includes such processes as abrasive blasting and power tool cleaning. The chemical cleaning processes include both mineral acids and organic acids. Mineral acids include sulfuric acid, hydrochloric acid and phosphoric acid. Organic acids include oxalic, acetic, tannic and citric.

Even though not commonly known, organic acid cleaning is an older process than the mineral acid processes. In fact, the term “pickling” of steel was derived from the early use of acetic acid (vinegar) for derusting steel.[8]

One organic acid which is readily available commercially is citric acid. This acid, which is correctly called 2-hydroxy-1, 2, 3 propanetricarboxylic acid is a hydroxy tribasic organic acid with the following formula:

```
      H  O
      |
    H-C-C~O-H
      O
  H-O-C-C~O-H
      O
    H-C-C~O-H
      |
      H
```

Because of the chemical nature of citric acid, it has the ability to chelate metal ions through attached carboxyl (COOH) and hydroxyl (OH) groups. This chemical property makes citric acid an excellent material for pickling of steel to remove corrosion products (rust).

In proper concentrations and at the proper temperature, citric acid will attack and dissolve iron oxide with minimum corrosive affect on the base metal.[1] However, if citric acid is used without other additives to promote the sequestering of the removed iron ions, the chelated metal ions will precipitate as insoluble citrate salts as the citric acid is consumed.[10]

One such additive which has been used with success in the past is ammonium hydroxide.[1,10] Ammoniated citric acid has been successfully used to spray derust sections of a ship's hull.[1] The primary drawback to using ammoniated citric acid is the formation of noxious fumes of ammonia at process design working conditions. This unpleasantness can be overcome by substituting other additives such as triethanolamine (TEA)[1,10] In addition to not being noxious, the mixture of citric acid and triethanolamine is not harmful to personnel exposed to cooled spray or runoff.[10]

Citric/TEA cleaning solutions readily chelate ferric rust.[10] Magnetite, however, is more difficult to remove depending on the crystalline structure and the presence of other oxides. These points must be taken into account when performing cleaning operations. Telltale signs are the presence of small black particles remaining on the steel surface after cleaning.

The rate of reaction between the iron oxide and the citric acid/TEA cleaning solution is dependent upon the following:

- Temperature
- Strength
- Agitation

Generally speaking the higher the temperature, the faster the reaction. In some cases, the cleaning rate can be doubled for each 20°F rise in temperature between 70°F and 210°F.[8] However, care must be exercised not to exceed the decomposition temperature for the components in solution.

Cleaning solution strength (concentration) and agitation are also important. Agitation helps by permitting fresh acid to come in contact with the steel surface. Solution strength has a direct effect on the amount of iron oxide which can be dissolved and held in solution. Over concentration retards dissociation of the acid.

The use of citric acid/TEA cleaning solutions has two limitations. The rate at which citric acid attacks mill scale is so slow as to preclude its use as an effective descaling process. Therefore, mill scale must be removed at some point prior to the use of citric acid. In shipbuilding, This can be accomplished using an abrasive descaling machine for all plates and shapes prior to steel fabrication.

The second limitation concerns the removal of organic contamination. Even though rust is effectively removed, the acid solution will not remove oil, grease, wax or other organic soil contamination. This fact is also true of both mineral acid cleaning operations and mechanical cleaning operations.

The primary advantage in using citric acid/TEA cleaning processes is the reduction of pollution problems. Spent cleaning solutions can be disposed of by one or more of the following:[10]

- Incineration
- Biodegradation
- Chemical Treatment

Used solutions can easily be disposed of by the burning of the used solution in a boiler or other incineration device. The byproducts are carbon dioxide and water. The metal ions end up in the boiler slag.[10] Long Island Lighting was the first company to receive approval from a State Regulatory Agency to burn an ammoniated citric acid solution.

In test carried out by Pfizer, Incorporated, citric acid solutions were found to be readily biodegradable. Citrate chelates of various metals underwent rapid biological degradation.[1]

Heavy metals and other contaminants can also be removed electrochemically prior to discarding the spent acid or reusing it. This can be accomplished with the use of ion exchange resins, electrodialysis, or inorganic reduction.[1,10]

The relative economics of using citric acid cleaning processes have not been quantified to date. In general, the material cost of organic acids is greater than that of mineral acids; however, because of the ease with which spent citric acid can be disposed of, the total cost of using citric acid could be far less than for mineral acids. The same rationale could hold true for comparing the bottom line cost of uncontained abrasive blasting which includes removal of abrasive blast residues.

The next point which must be discussed is the passivation of the derusted steel. Even though not as severe as with the use of mineral acids, citric acid/TEA cleaned steel will flash rust following final rinse. To overcome this problem, any of a number of commercially available proprietary or generic passivators could be used. Sodium Nitrite is one example. Because of the complex nature of the mechanism of passivated films, their discussion is beyond the scope of this document. It suffices to state that passivators react with the cleaned iron surface and form a chemical complex which retardsrusting until such time as paint can be applied.

2.2 Objective

The overall objective is the investigation of the possible use of a citric acid cleaning process as a viable substitute for present means of surface preparation prior to painting during new ship construction.

2.2.1 Phase I - Phase I (this study) was designed to determine top coat compatibilities of the commonly used marine coatings with citric acid cleaned surfaces. This objective was achieved.

2.2.2 Phase II - Since Phase I was a success, a Phase II program is warranted in which economic evaluation can be made and practical, environmentally acceptable equipment and processes can be selected or developed.

2.3 Plan of Action

As stated above, the initial step of any proposed new surface preparation method must be to determine the compatibility of present state-of-the-art

- Exterior Marine Test Fence Exposure of Primers Only
- Aged Weather-Ometer Adhesion of Exterior Paint Systems
- Salt Fog Cabinet Testing for Exterior Paint Systems
- Hydrostatic Test Chamber Exposure for Tank Coatings

These tests were selected to evaluate the more severe ship exposure areas excluding the underwater bottom. The hydrostatic test chamber test provided some data on immersion resistance.

All tests were designed to compare the relative performances of selected coatings and/or coating systems when applied over both abrasive blasted surfaces and citric acid cleaned surfaces, i.e. abrasive blast surface preparation was selected as a control.

2.4 Process Development

The primary consideration in developing the laboratory cleaning process was to create a substrate which would be representative of a surface achieved in actual production. A-36 steel panels were descaled using air abrasive blast and the descaled panels were allowed to rust in an outside marine environment.

The initial attempt at derusting utilized a high pressure spray. The high pressure spray was achieved with an airless paint pump with a 23:1

ratio and an inlet air pressure of 100 psi. The capacity of this small pump was 0.67 gallons per minute. The small volume of the pump combined with the cooling effect of the atomization of material was such that the maximum operating temperature achieved at the steel substrate was only 139°F. The inability to achieve the required minimum temperature of 180°F dictated use of an alternate method. The final technique was immersion of the panels in a tank filled with the heated acid solution (See Figure 2.2). At this point it must be pointed out that the spray cleaning did remove the ten week rust accumulation but it took over an hour.

Before the immersion technique was finally selected, the surfaces of representative steel panels cleaned via immersion and spray were examined using a scanning electron microscope. There was no detectable physical or chemical difference in the surface of the panels cleaned via spray as opposed to immersion.

2.4.1 Final Process

2.4.1.1 Step One - Steel panels were descaled by abrasive blasting using a coal slag abrasive and air blast equipment. The descaled panels were then allowed to rust in an outside marine environment for a minimum of eight weeks. A heavy rust formed during this time. (See Figure 2.1).

2.4.1.2 Step Two - The rusty steel panels were immersed in the acid cleaning tank for one hour. (See Figure 2.2) The composition of the acid cleaning solution was as follows:

- Citric Acid 6% by weight
- Triethanolamine (TEA) 4% by weight
- Thiourea 1% by weight
- Tap Water - Remainder

The temperature of the solution was 180-185°F; the pH was 3.7.

2.4.1.3 Step Three - The cleaned panels were removed from the acid cleaning solution and placed on a cleaning rack. (See Figure 2.3, Note the Heavy smut accumulation at this point).

2.4.1.4 Step Four - Desmutting of the derusted panels using high pressure spray (2000+ psi at the nozzle). (See Figure 2.4) At first, fresh water was used for this purpose, but later changed to use the passivator solution. The

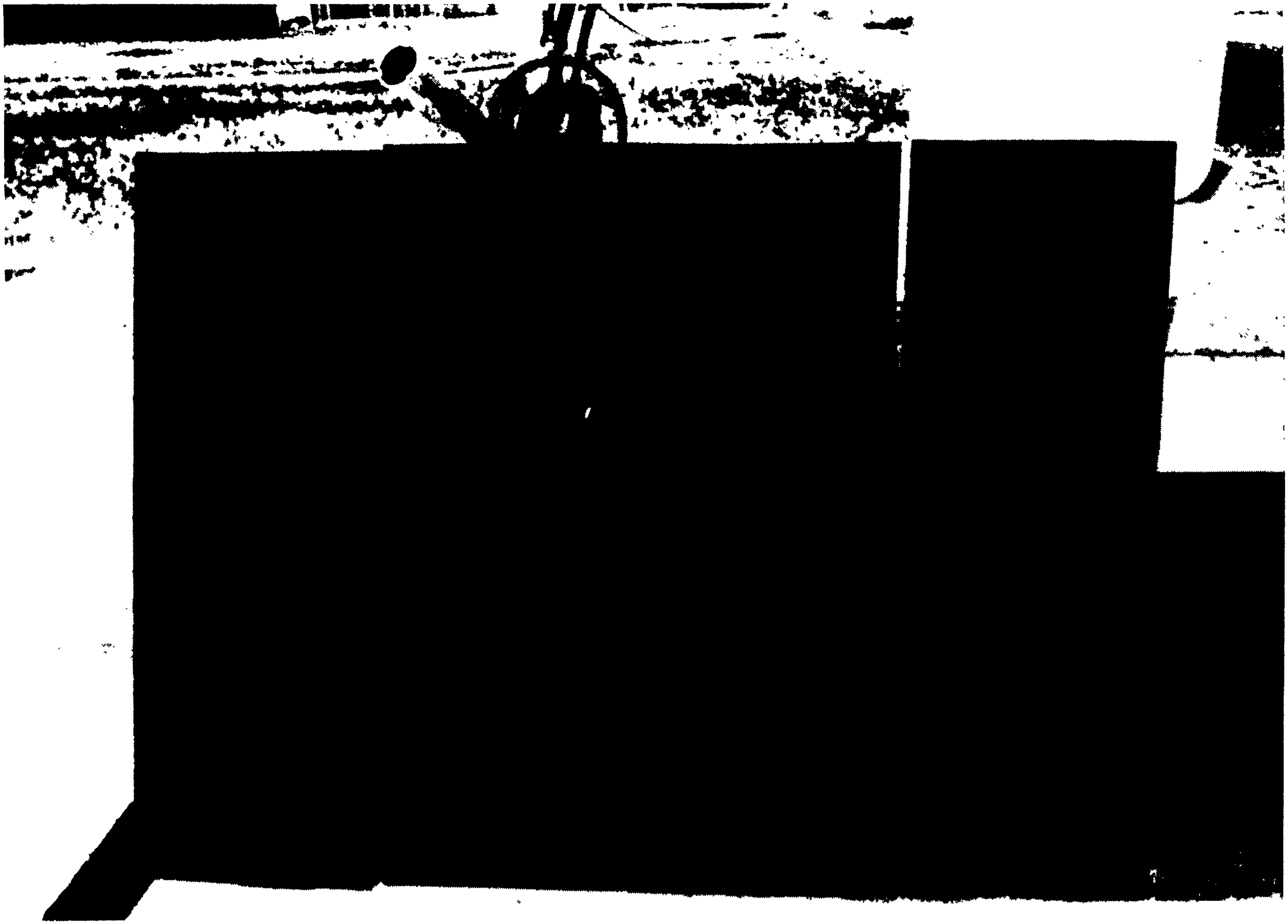


Figure 2.1: Steel Panels Prior to Cleaning

Figure 2.2: Laboratory Citric Acid Cleaning Apparatus

Figure 2.3: Steel Panel Being Removed From
Citric Acid Cleaning Tank

Figure 2.4: Desmutting Operation

Figure 2.5: Spray Passivation

passivator solution desmutting step could not be used in confined areas due to the formation of toxic nitric oxide.

2.4.1.5 Step Five - The panels were intermittently spray passivated with the passivator for fifteen minutes. (See Figure 2.5) The panels were kept wet during this step. The composition of the passivator was:

- Sodium Nitrite 1% by weight
- Sodium Citrate 2% by weight
- Tap Water Remainder

2.4.1.6 Step Six - The final operation was fresh water rinse with ambient temperature water. This step became the most important and the most difficult to control. Initially tap water was used. Some panels dried rust free and some panels flash rusted. An investigation into this phenomenon revealed that the chemical composition of tap water was critical. The tap water intially used had a chemical composition of:

1.4 ppm Free Chlorine
125 ppm Sulfate
95 ppm Chloride (as Sodium Chloride)

Rinse water solutions were made with each of these ingredients present in solution alone. Sample panels were then cleaned via the developed process except that two panels each were rinsed with one of the single ingredient solutions. Free chlorine from the chlorination had no effect on flash rusting. The sulfate and chloride solutions both resulted in flash rusting.

This finding is reinforced by the work of G. W. Mellors, et al on the effects of chloride ion on films formed in sodium nitrite solutions.[5] The Bibliography in Section 3 contains two other papers on the discussion of this subject. The final rinse water used to achieve flash rust free panels contained reduced chloride and sulfate levels (<50 ppm). Figure 2.7 shows the force drying of panels. This requirement was later deleted. Figure 2.8 shows the end result and should be compared with Figure 2.1 to judge success.

Figure 2.6: Final Rinse

Figure 2.7: Panels Air Drying

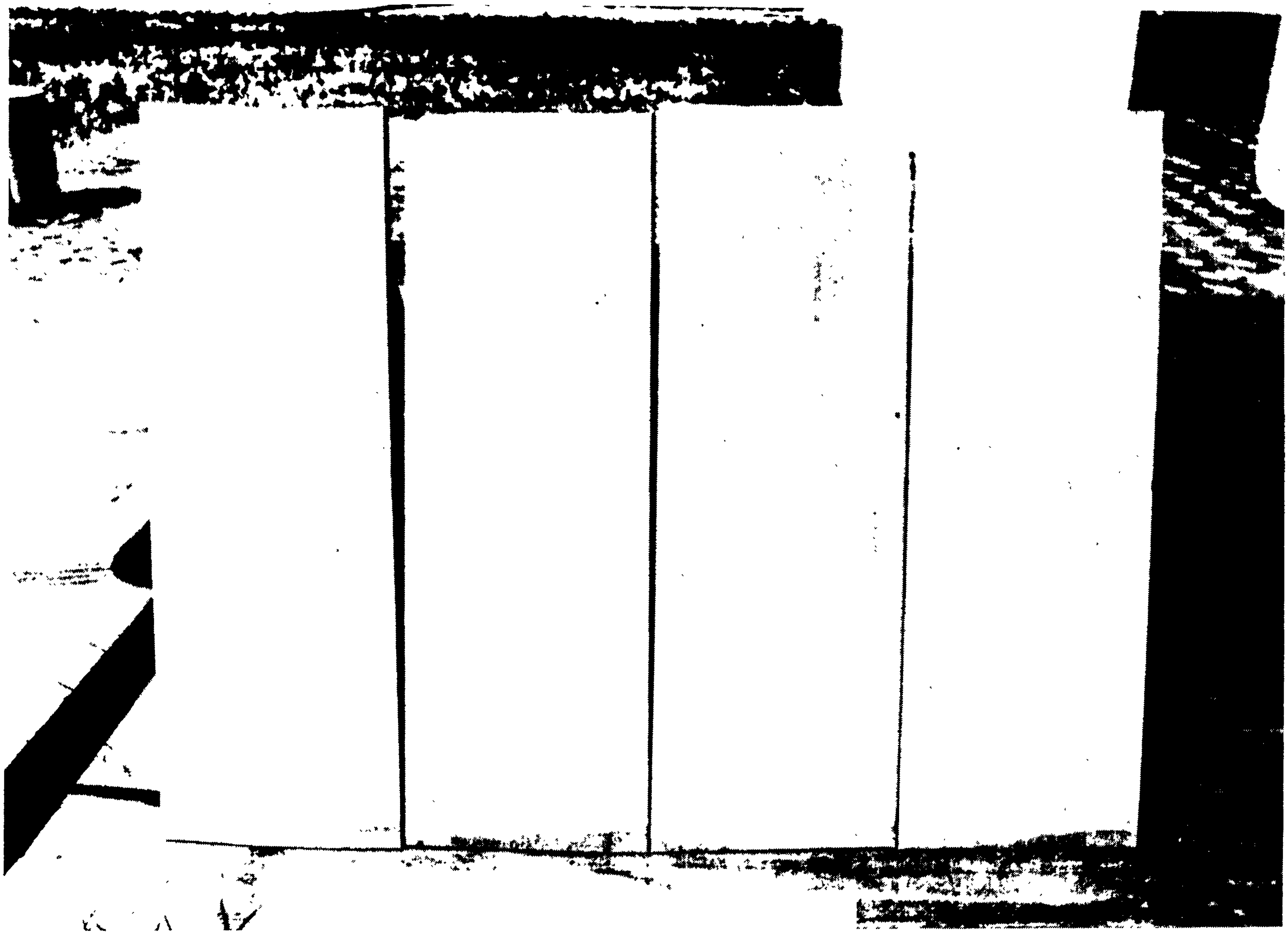


Figure 2.8: Steel Panels After Citric Acid Cleaning and Passivat·on

2.4.2 Results of Cleaning Process

Figure 2.9 is a photomicrograph of the citric acid cleaned and passivated steel surface at lOOX. Figure 2.10 is a photomicrograph of an abrasive blasted panel at the same magnification. Note the particles of coal slag embedded in the abrasive blasted panel. This phenomenon is not unusual.

The primary difference in the topography of these two surfaces is the spongy or cob web appearance of the citric acid cleaned surface. This is a result of the removal of the corrosion products thus leaving numerous minute pockets or voids. Also note that all entrapped abrasive particles have been removed.

Chemical analysis of the surface showed the same chemistry for both substrates with the exception that no silicates were present on the citric acid cleaned panels whereas they were present on the abrasive blasted panel. Again this demonstrated that the blasting residue was not present on the citric acid cleaned panel.

Figure 2.11 is a photograph comparing abrasive blast cleaned steel panels to citric acid cleaned panels.

2.5 Laboratory Test Results

Each test set up was designed to simulate marine exposures. The following paragraphs discuss each test environment and the results.

2.5.1 Salt Spray Exposure

This test series was designed to simulate exterior exposure in a marine environment. Thirty different paint systems applied over both citric acid cleaned and abrasive blast cleaned panels were exposed to ASTM B-117 “Salt Spray (Fog) Test” for 2500 hours. KTA panels were used to simulate welded structures. These panels are 4” X 6“, A-36 steel, with a welded channel. Prior to final cleaning both sets (abrasive blast and citric acid) of panels were descaled and allowed to rust in a marine environment for eight weeks. The generic systems tested are as follows:

- Inorganic zinc/Epoxy/Polyurethane - 2 each
- Inorganic zinc/Vinyl - 4 each
- Inorganic zinc/Chlorinated Rubber - 3 each
- Inorganic zinc/Chlorinated Rubber/Modified Acrylic - 1 each
- Epoxy - 3 each
- Alkyd - 4 each
- Inorganic zinc/Epoxy - 4 each

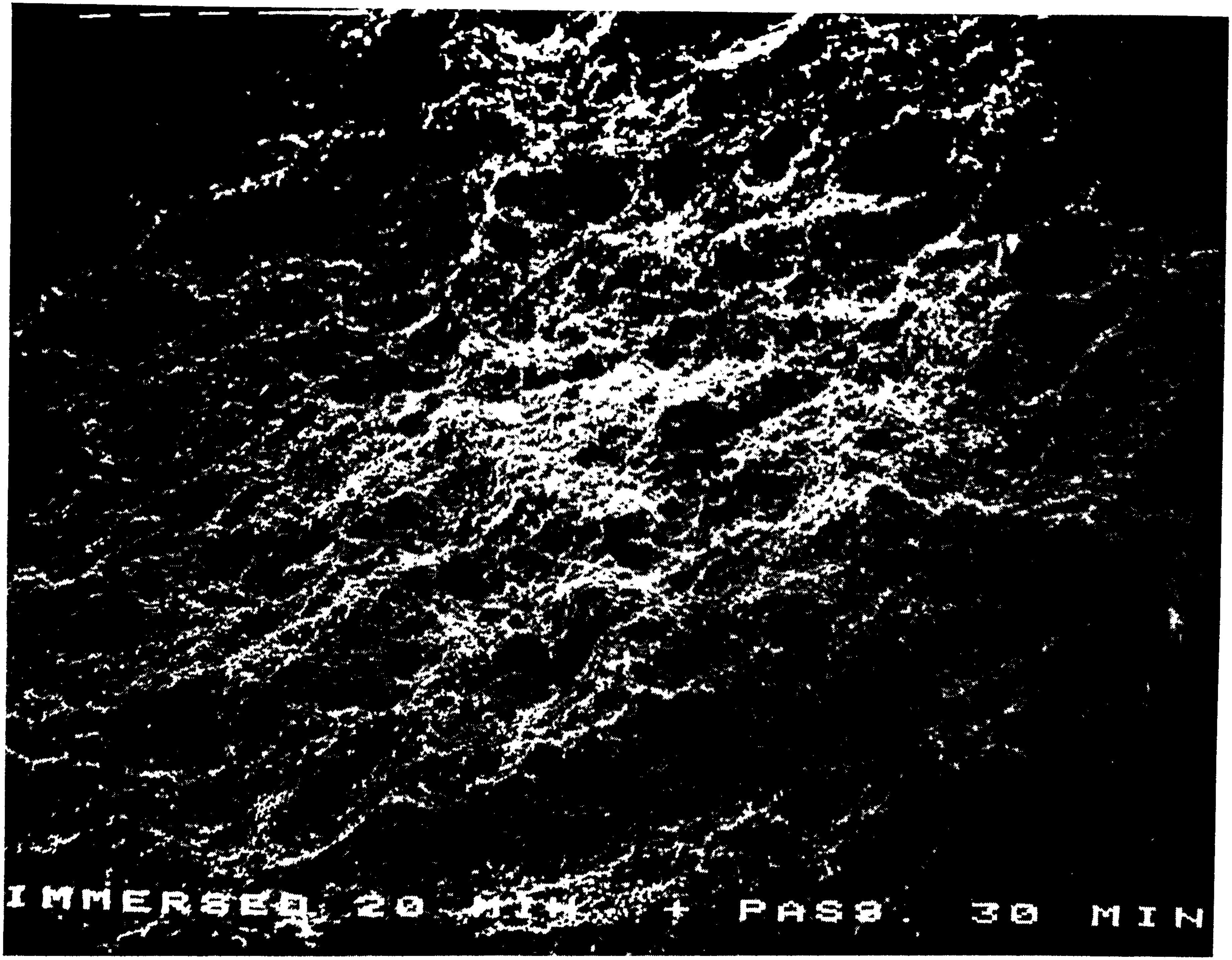


Figure 2.9: SEM Photomicrograph of Citric Acid Cleaned and Passivated Steel (100X)

Figure 2.10: SEM Photomicrograph of Abrasive Blasted Steel (100X)

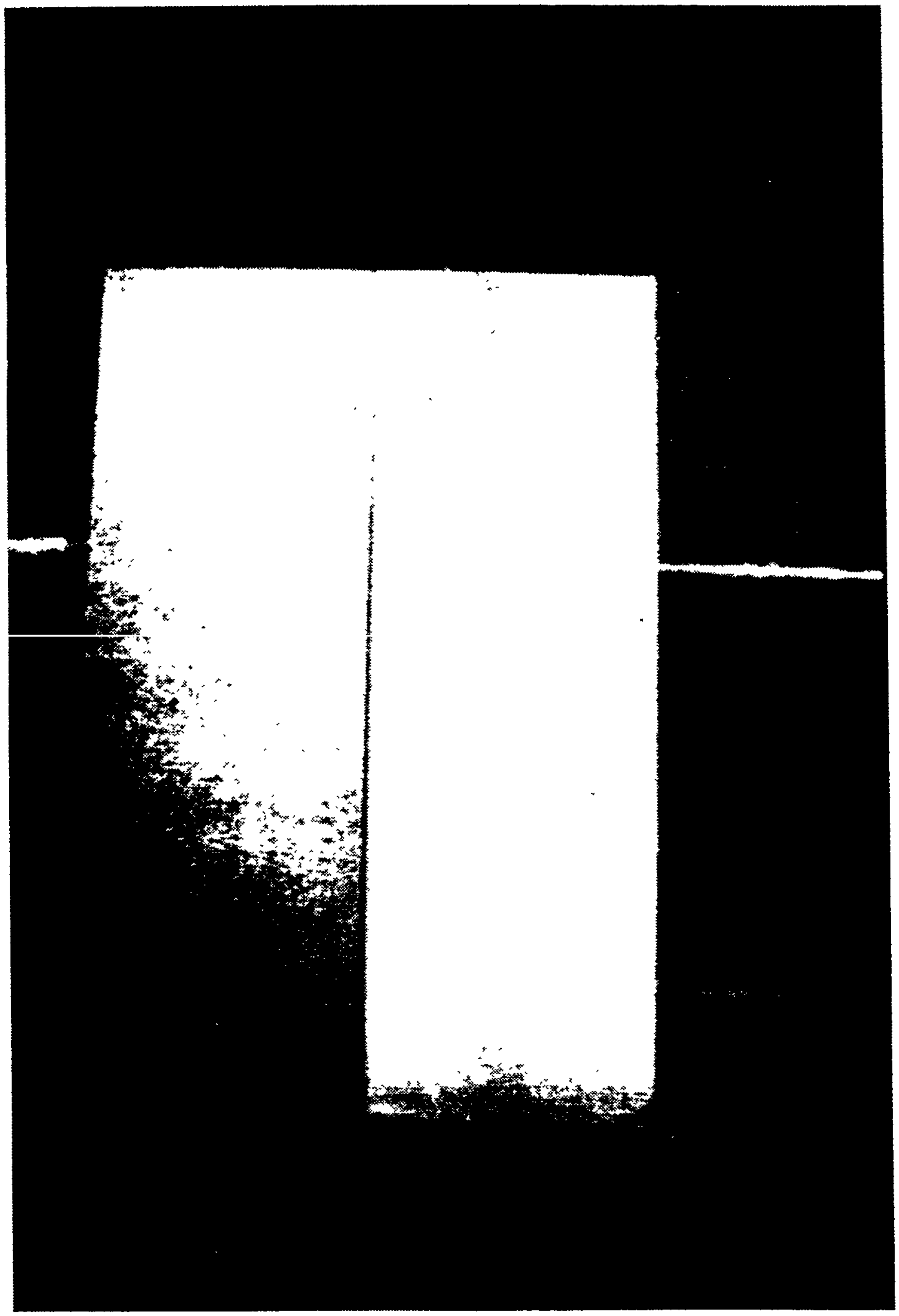


Figure 2.11: Comparison of Abrasive Blast and Citric Acid Cleaned Panels (Blast-left; Acid-right)

Coal Tar Epoxy - 2 each

- Inorganic zinc/Epoxy/Alkyd - 2 each
- Chlorinated Rubber -2 each
- Vinyl - 2 each
- Epoxy/Polyurethane - 1 each

The systems tested were selected randomly from different suppliers. The vendor application instructions concerning mixing, drying, curing, overcoating and application were followed. The one exception was film thickness. No attempt was made to control film thickness precisely between suppliers; however, attempts were made to apply the same quantity of material to both the abrasive blasted panel and the citric acid panel within a set. For this reason, no attempt should be made to compare performance between suppliers. An attempt to compare suppliers could lead to erroneous conclusions.

Table I summarizes the exact systems tested and the relative performance of each. Rust grades were determined in accordance with ASTM D610. Figures 2.12 through 2.23 are photographs of the actual panels at the completion of the test.

A statistical analysis to evaluate the central tendency of the data was performed on the entire set of abrasive blasted panels and citric acid panels. No attempt was made toward an analysis of variance as concerns generic type of material. It is a widely accepted fact that certain types of generic paints do out perform other generic types. Keeping this in mind, the following performance information is presented (10 is perfect; O is complete failure).

TABLE IA - Statistical Comparison of Relative Salt Spray Performance

	ABRASIVE BLAST	CITRIC ACID
Observation Range	lto9	2to9
Mean	7.63	8.07
Standard Deviation	2.57	2.02
Mode	9 occurrences 19	9 occurrences 20
Median	9	9

When comparing the data of Table IA, it can be seen that, in general, citric acid cleaned panels perform as well as or better than abrasive blasted panels exposed to salt spray for 2500 hours.

TABLE I: Salt Spray (ASTM B117) Corrosion Resistance of

Various Generic Coatings Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Steel Panels (Graded in Accordance with ASTM D610; 10 is Perfect)

SUPPLIER	SYSTEM CODE	SURFACE PREPARATION	FIRST COAT		SECOND COAT		THIRD COAT		FOURTH COAT		RATING AFTER 2500 HRS	PHOTOGRAPHIC FIGURE NUMBER
			PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)		
Ameron	AB1	Abrasive Blast (SP10)	D-6, Alkyl Inorganic Zinc	3.0	383, Polyamide Epoxy	5.0	450, Aliphatic Polyurethane	2.0	NONE		9	2.12
Ameron	AC1	Citric Acid	D-6, Alkyl Inorganic Zinc	3.0	383, Polyamide Epoxy	5.0	450, Aliphatic Polyurethane	2.0	NONE		9	2.12
Byco	BB1	Abrasive Blast (SP10)	102SP92, One Package Inorganic Zinc	3.0	300HB, Polyamide Epoxy	5.0	902, Aliphatic Polyurethane	2.0	NONE		9	2.12
Byco	BC1	Citric Acid	102SP92, One Package Inorganic Zinc	3.0	300HB, Polyamide Epoxy	5.0	902, Aliphatic Polyurethane	2.0	NONE		9	2.12
Ameron	AB2	Abrasive Blast (SP10)	D-6, Alkyl Inorganic Zinc	3.0	54TC, Synthetic Resin Tie Coat	1.5	99, Vinyl	2.0	99, Vinyl	2.0	9	2.13
Ameron	AC2	Citric Acid	D-6, Alkyl Inorganic Zinc	3.0	54TC, Synthetic Resin Tie Coat	1.5	99, Vinyl	2.0	99, Vinyl	2.0	9	2.13
Carboline	CB2	Abrasive Blast (SP10)	CZ11, Alkyl Inorganic Zinc	3.0	935TC, Vinyl Tie Coat	1.5	938, Vinyl	3.0	938, Vinyl	3.0	9	2.13
Carboline	CC2	Citric Acid	CZ11, Alkyl Inorganic Zinc	3.0	935TC, Vinyl Tie Coat	1.5	938, Vinyl	3.0	938, Vinyl	3.0	9	2.13
Mobil	GB2	Abrasive Blast (SP10)	13F12, Alkyl Inorganic Zinc	3.0	80R8, Vinyl Primer	1.5	83F34, Vinyl	4.0	NONE		8	2.13
Mobil	GC2	Citric Acid	13F12, Alkyl Inorganic Zinc	3.0	80R8, Vinyl Primer	1.5	83F34, Vinyl	4.0	NONE		9	2.13
Porter	JB2	Abrasive Blast (SP10)	352, Alkyl Inorganic Zinc	1.5	1799, Vinyl Wash Primer	0.5	VC37, Vinyl	3.5	NONE		6	2.13

TABLE I: (cont'd.)

TABLE I: Salt Spray (ASTM B117) Corrosion Resistance of Various Generic Coatings Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Steel Panels (Graded in Accordance with ASTM D610; 10 is Perfect)

SUPPLIER	SYSTEM CODE	SURFACE PREPARATION	FIRST COAT		SECOND COAT		THIRD COAT		FOURTH COAT		RATING AFTER 2500 HRS	PHOTOGRAPHIC FIGURE NUMBER
			PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)		
Porter	JC2	Citric Acid	352, Alkyl Inorganic Zinc	1.5	1799, Vinyl Wash Primer	0.5	VC37, Vinyl	3.5	NONE		8	2.13
Ameron	AB3	Abrasive Blast (SP10)	D-6, Alkyl Inorganic Zinc	3.0	2015, Chlorinated Rubber	2.0	524, Chlorinated Rubber	4.0	NONE		9	2.14
Ameron	AC3	Citric Acid	D-6, Alkyl Inorganic Zinc	3.0	2015, Chlorinated Rubber	2.0	524, Chlorinated Rubber	4.0	NONE		9	2.14
Napko	IB3	Abrasive Blast (SP10)	1375, Alkyl Inorganic Zinc	3.0	8-4137, Chlorinated Rubber	2.0	8-4137, Chlorinated Rubber	4.0	NONE		9	2.14
Napko	IC3	Citric Acid	1375, Alkyl Inorganic Zinc	3.0	8-4137, Chlorinated Rubber	2.0	8-4137, Chlorinated Rubber	4.0	NONE		8	2.14
Ameron	KB3	Abrasive Blast (SP10)	D-9, Alkyl Inorganic Zinc	3.0	2015, Chlorinated Rubber	2.0	524, Chlorinated Rubber	4.0	NONE		9	2.14
Ameron	KC3	Citric Acid	D-9, Alkyl Inorganic Zinc	3.0	2015, Chlorinated Rubber	2.0	524, Chlorinated Rubber	4.0	NONE		9	2.14
Ameron	AB4	Abrasive Blast (SP10)	D-9, Alkyl Inorganic Zinc	3.0	2015, Chlorinated Rubber	2.0	234, Modified Acrylic	2.5	NONE		9	2.15
Ameron	AC4	Citric Acid	D-9, Alkyl Inorganic Zinc	3.0	2015, Chlorinated Rubber	2.0	234, Modified Acrylic	2.5	NONE		9	2.15
Ameron	AB5	Abrasive Blast (SP10)	71, Polyamide Epoxy	2.0	383, Polyamide Epoxy	5.0	NONE				9	2.16
Ameron	AC5	Citric Acid	71, Polyamide Epoxy	2.0	383, Polyamide Epoxy	5.0	NONE				8	2.16

TABLE I: (cont'd.)

TABLE I: Salt Spray (ASTM B117) Corrosion Resistance of
Various Generic Coatings Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned
Steel Panels (Graded in Accordance with ASTM D610; 10 is Perfect)

SUPPLIER	SYSTEM CODE	SURFACE PREPARATION	FIRST COAT		SECOND COAT		THIRD COAT		FOURTH COAT		RATING AFTER 2500 HRS	PHOTOGRAPHIC FIGURE NUMBER
			PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)		
Carboline	CB5	Abrasive Blast (SP10)	193, Polyamide Epoxy	3.0	190HB, Polyamide Epoxy	6.0	NONE				9	2.16
Carboline	CC5	Citric Acid	193, Polyamide Epoxy	3.0	190HB, Polyamide Epoxy	6.0	NONE				9	2.16
Devoe	DB5	Abrasive Blast (SP10)	201, Polyamide Epoxy	2.0	230, Epoxy	6.0	229, Arcylic Modified Epoxy	2.0	NONE		8	2.16
Devoe	DC5	Citric Acid	201, Polyamide Epoxy	2.0	230, Epoxy	6.0	229, Arcylic Modified Epoxy	2.0	NONE		9	2.16
Byco	BB6	Abrasive Blast (SP10)	400-2, Alkyd	2.0	800, Alkyd	1.5	800, Alkyd	1.5	NONE		1	2.17
Byco	BC6	Citric Acid	400-2, Alkyd	2.0	800, Alkyd	1.5	800, Alkyd	1.5	NONE		2	2.17
Imperial	EB6	Abrasive Blast (SP10)	62, Alkyd	2.0	84, Alkyd	2.5	84, Alkyd	2.5	NONE		2	2.17
Imperial	EC6	Citric Acid	62, Alkyd	2.0	84, Alkyd	2.5	84, Alkyd	2.5	NONE		8	2.17
Mobil	GB6	Abrasive Blast (SP10)	53R1, Alkyd	2.0	20F34, Alkyd	1.5	20F34, Alkyd	1.5	NONE		7	2.17
Mobil	GC6	Citric Acid	53R1, Alkyd	2.0	20F34, Alkyd	1.5	20F34, Alkyd	1.5	NONE		7	2.17
Mobile	HB6	Abrasive Blast (SP10)	28DR105, Alkyd	2.0	Alkyd	2.0	Alkyd	2.0	NONE		1	2.17

TABLE I: (cont'd.)

TABLE I: Salt Spray (ASTM B117) Corrosion Resistance of Various Generic Coatings Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Steel Panels (Graded in Accordance with ASTM D610; 10 is Perfect)

SUPPLIER	SYSTEM CODE	SURFACE PREPARATION	FIRST COAT		SECOND COAT		THIRD COAT		FOURTH COAT		RATING AFTER 2500 HRS	PHOTOGRAPHIC FIGURE NUMBER
			PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)		
Mobile	HC6	Citric Acid	28DR105, Alkyd	2.0	Alkyd	2.0	Alkyd	2.0	NONE		3	2.17
Carboline	CB7	Abrasive Blast (SP10)	CZ11, Alkyl Inorganic Zinc	3.0	190HB, Polyamide Epoxy	6.0	NONE				9	2.18
Carboline	CC7	Citric Acid	CZ11, Alkyl Inorganic Zinc	3.0	190HB, Polyamide Epoxy	6.0	NONE				9	2.18
Devoe	DB7	Abrasive Blast (SP10)	302, Modified Inorganic Zinc	3.0	230, Epoxy	6.0	229, Acrylic Modified Epoxy	1.5	NONE		9	2.18
Devoe	DC7	Citric Acid	302, Modified Inorganic Zinc	3.0	230, Epoxy	6.0	229, Acrylic Modified Epoxy	1.5	NONE		9	2.18
International	FB7	Abrasive Blast (SP10)	2410/2411, Alkyl Inorganic Zinc	3.0	8967/1534C Epoxy	4.0	NONE				9	2.18
International	FC7	Citric Acid	2410/2411, Alkyl Inorganic Zinc	3.0	8967/1534C Epoxy	4.0	NONE				9	2.18
Devoe	LB7	Abrasive Blast (SP10)	302, Modified Inorganic Zinc	3.0	224, Polyamide Epoxy	6.0	229, Acrylic Modified Epoxy	1.5	NONE		9	2.18
Devoe	LC7	Citric Acid	302, Modified Inorganic Zinc	3.0	224, Polyamide Epoxy	6.0	229, Acrylic Modified Epoxy	1.5	NONE		9	2.18
Carboline	CB8	Abrasive Blast (SP10)	CM14, Coal Tar Epoxy	8.0	CM14, Coal Tar Epoxy	8.0	NONE				9	2.19
Carboline	CC8	Citric Acid	CM14, Coal Tar Epoxy	8.0	CM14, Coal Tar Epoxy	8.0	NONE				9	2.19

TABLE I: (cont'd.)

TABLE I: Salt Spray (ASTM B117) Corrosion Resistance of Various Generic Coatings Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Steel Panels (Graded in Accordance with ASTM D610; 10 is Perfect)

SUPPLIER	SYSTEM CODE	SURFACE PREPARATION	FIRST COAT		SECOND COAT		THIRD COAT		FOURTH COAT		RATING AFTER 2500 HRS	PHOTOGRAPHIC FIGURE NUMBER
			PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)		
International	FB8	Abrasive Blast (SP10)	C200, Coal Tar Epoxy	6.0	C200, Coal Tar Epoxy	6.0	NONE				8	2.19
International	FC8	Citric Acid	C200, Coal Tar Epoxy	6.0	C200, Coal Tar Epoxy	6.0	NONE				8	2.19
Imperial	EB9	Abrasive Blast (SP10)	512, Organic Zinc	3.0	1200, Polyamide Epoxy	6.0	84, Alkyd	2.5	NONE		9	2.20
Imperial	EC9	Citric Acid	512, Organic Zinc	3.0	1200, Polyamide Epoxy	6.0	84, Alkyd	2.5	NONE		9	2.20
Mobil	GB9	Abrasive Blast (SP10)	13F12, Alkyl Inorganic Zinc	3.0	89F15, Polyamide Epoxy	5.0	20F34, Alkyd	2.0	NONE		9	2.20
Mobil	GC9	Citric Acid	13F12, Alkyl Inorganic Zinc	3.0	89F15, Polyamide Epoxy	5.0	20F34, Alkyd	2.0	NONE		9	2.20
Imperial	EB10	Abrasive Blast (SP10)	880, Chlorinated Rubber	4.0	890, Chlorinated Rubber	2.5	NONE				2	2.21
Imperial	EC10	Citric Acid	880, Chlorinated Rubber	4.0	890, Chlorinated Rubber	2.5	NONE				2	2.21
Napko	IB10	Abrasive Blast (SP10)	5202, Chlorinated Rubber	4.0	8-4137, Chlorinated Rubber	2.0	8-4137, Chlorinated Rubber	2.0	NONE		8	2.21
Napko	IC10	Citric Acid	5202, Chlorinated Rubber	4.0	8-4137, Chlorinated Rubber	2.0	8-4137, Chlorinated Rubber	2.0	NONE		9	2.21
Mobil	GB11	Abrasive Blast (SP10)	13Y88, Vinyl Wash Primer	0.5	80R8, Vinyl	1.5	83F34, Vinyl	4.0	NONE		9	2.22

TABLE I: (cont'd.)

TABLE I: Salt Spray (ASTM B117) Corrosion Resistance of
Various Generic Coatings Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned
Steel Panels (Graded in Accordance with ASTM D610; 10 is Perfect)

SUPPLIER	SYSTEM CODE	SURFACE PREPARATION	FIRST COAT		SECOND COAT		THIRD COAT		FOURTH COAT		RATING AFTER 2500 HRS	PHOTOGRAPHIC FIGURE NUMBER
			PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)	PRODUCT NO. GENERIC TYPE	FILM THICK (MILS)		
Mobil	GC11	Citric Acid	13Y88, Vinyl Wash Primer	0.5	80R8, Vinyl	1.5	83F34, Vinyl	4.0	NONE		9	2.22
Napko	IB11	Abrasive Blast (SP10)	3326, Vinyl Wash Primer	0.5	1340, Vinyl	2.0	5422, Vinyl	5.0	NONE		7	2.22
Napko	IC11	Citric Acid	3325, Vinyl Wash Primer	0.5	1340, Vinyl	2.0	5422, Vinyl	5.0	NONE		8	2.22
Napko	IB12	Abrasive Blast (SP10)	5616, Polyamide Epoxy	4.0	5802, Polyamide Epoxy	5.0	5903, Polyurethane	2.0	NONE		9	2.23
Napko	IC12	Citric Acid	5616, Polyamide Epoxy	4.0	5802, Polyamide Epoxy	5.0	5903, Polyurethane	2.0	NONE		9	2.23

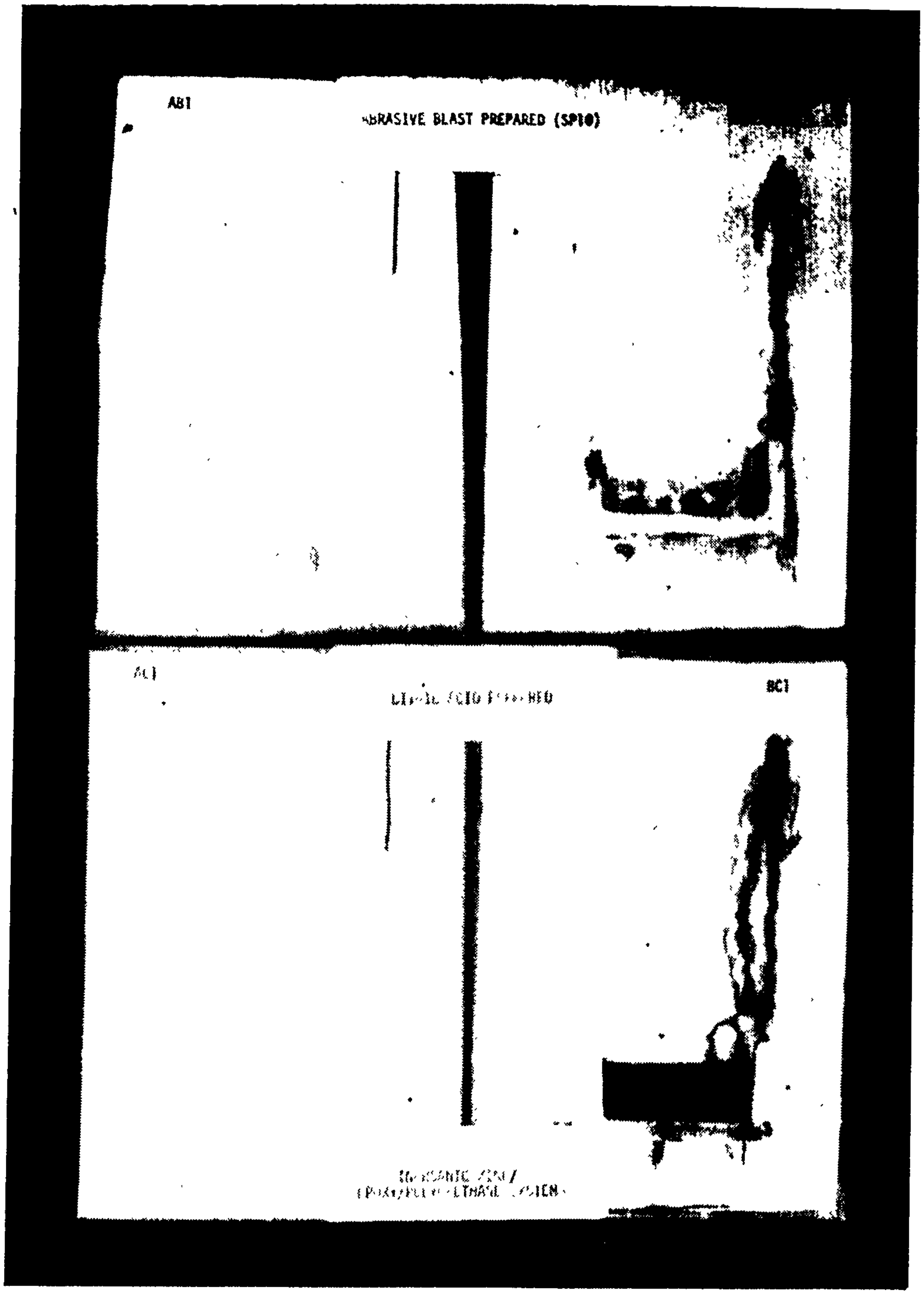


Figure 2.12: Abrasive Blast versus Citric Acid Cleaned Salt Spray Resistance of Inorganic Zinc, Polyamide Epoxy, Polyurethane Paint Systems

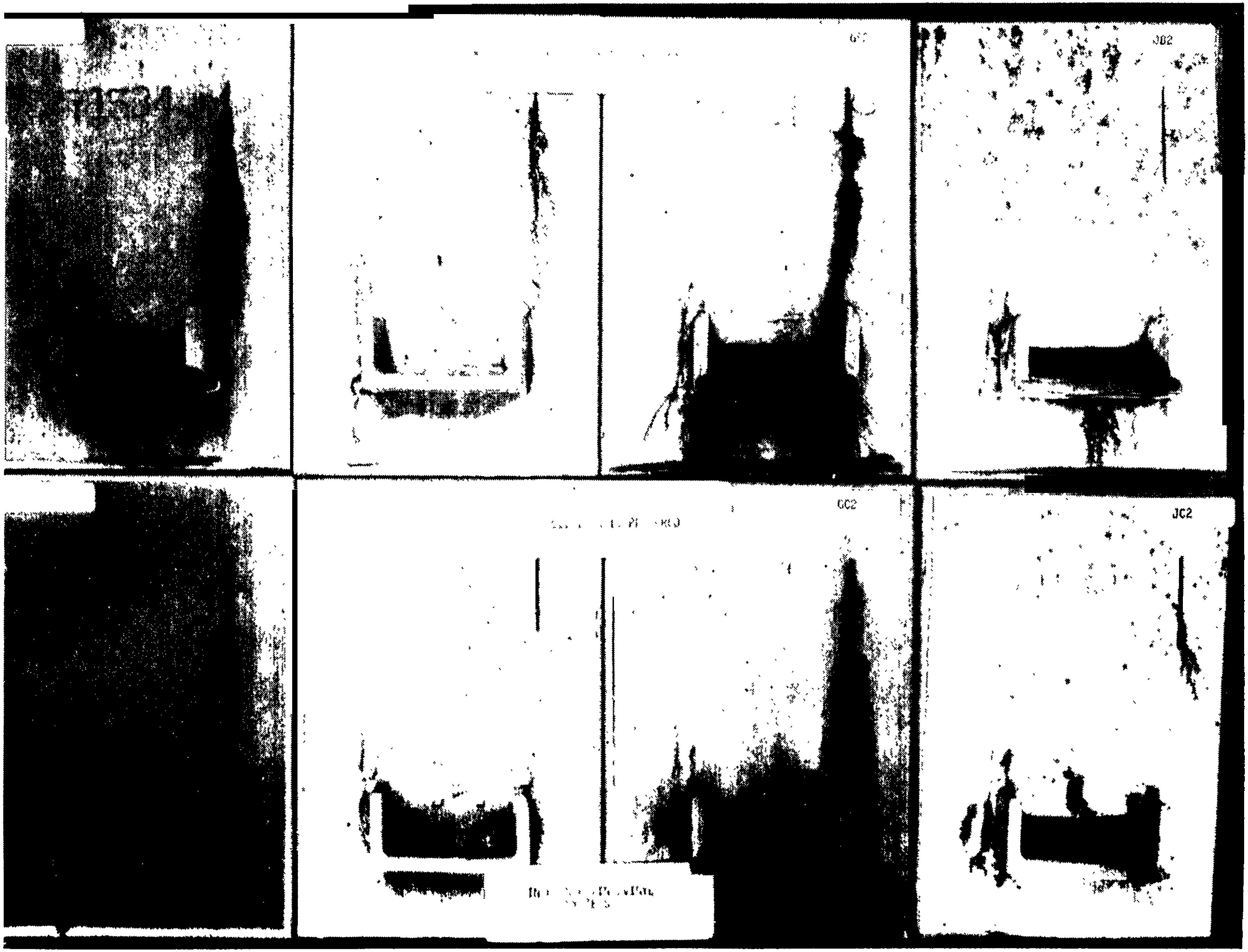
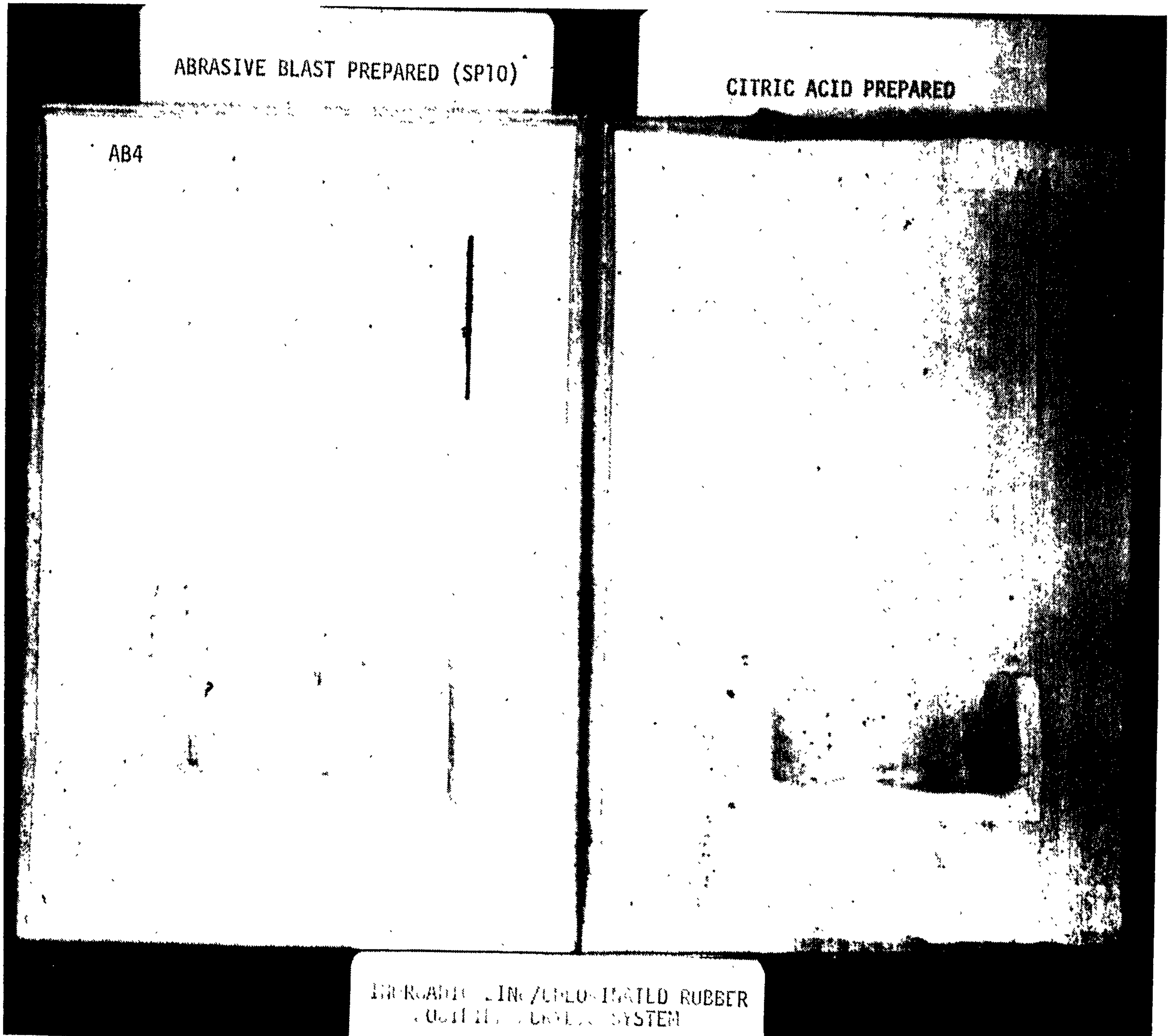


Figure 2.13: Abrasive Blast versus Citric Acid Cleaned Salt

Figure 2.14: Abrasive Blast versus Citric Acid Cleaned Salt Spray Resistance of Inorganic Zinc, Chlorinated Rubber Paint Systems


ABRASIVE BLAST PREPARED (SP10)
CITRIC ACID PREPARED
AB4
RUBBER
SYSTEM

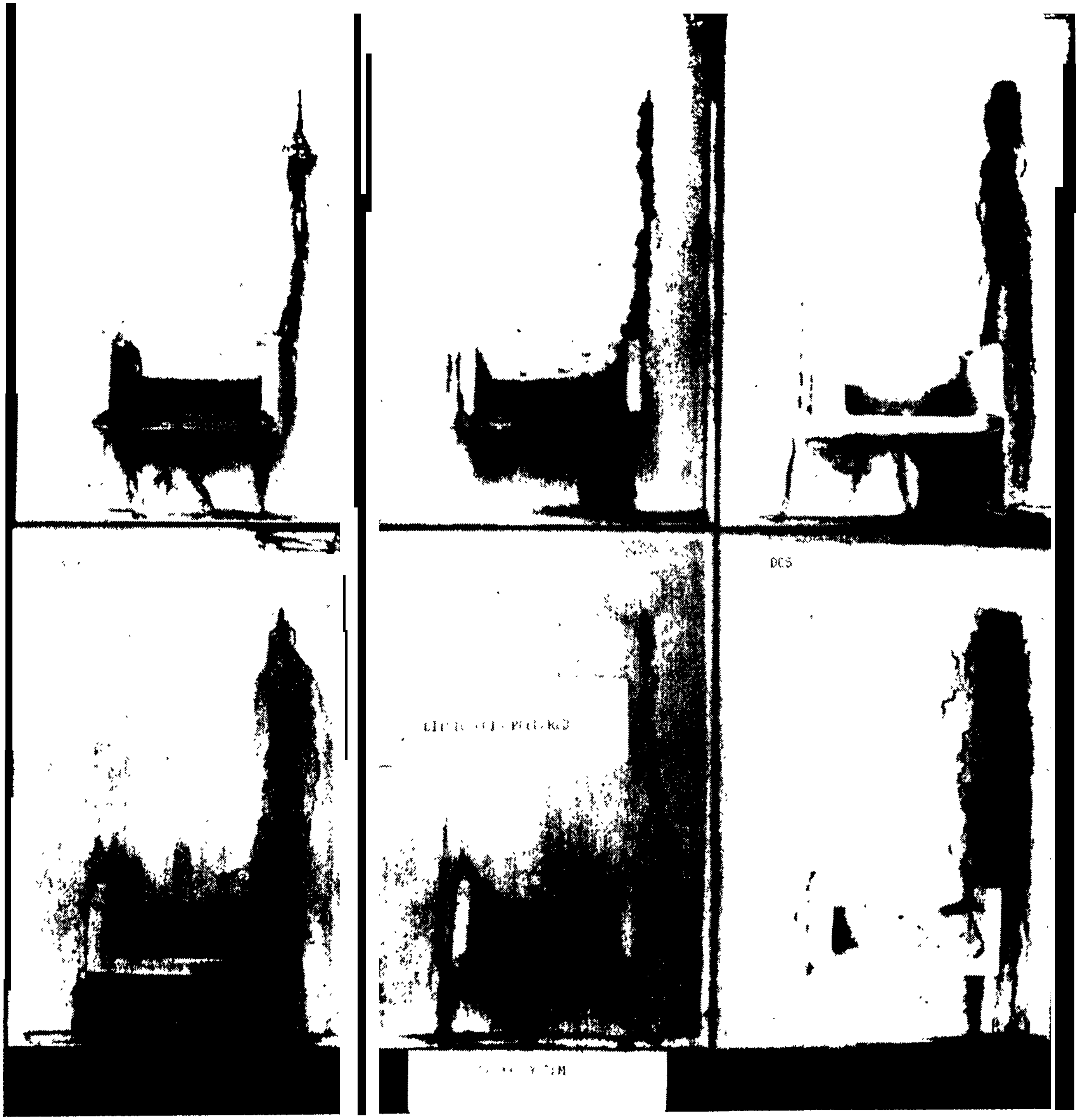


Figure 2.16: Abrasive Blast versus Citric Acid Cleaned
Salt Spray Resistance of Epoxy Paint Systems

Figure 3.15 Citric Acid Cleaning

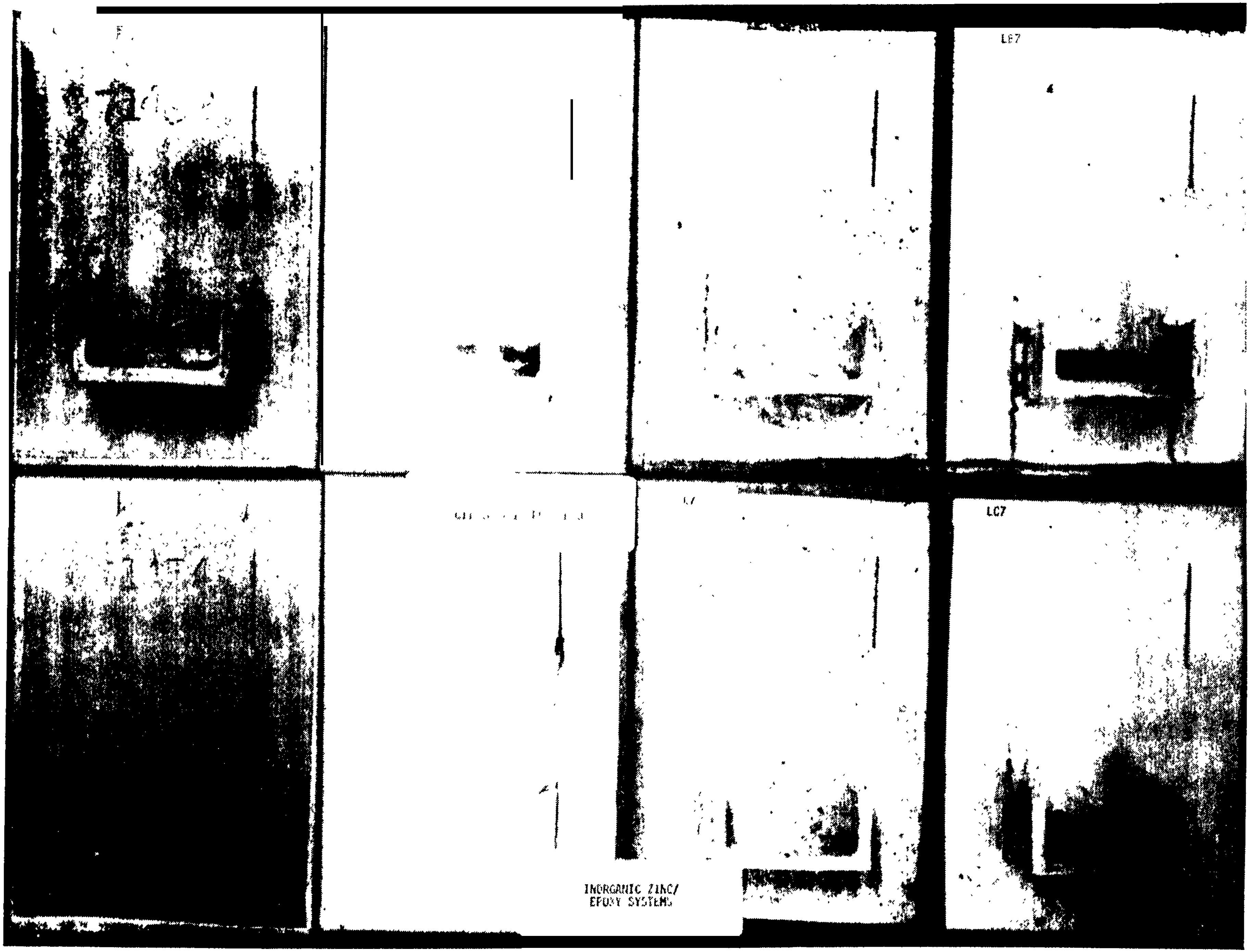


Figure 2.18: Abrasive Blast versus Citric Acid Cleaned
Salt Spray Resistance of Inorganic Zinc, Epoxy Paint Systems

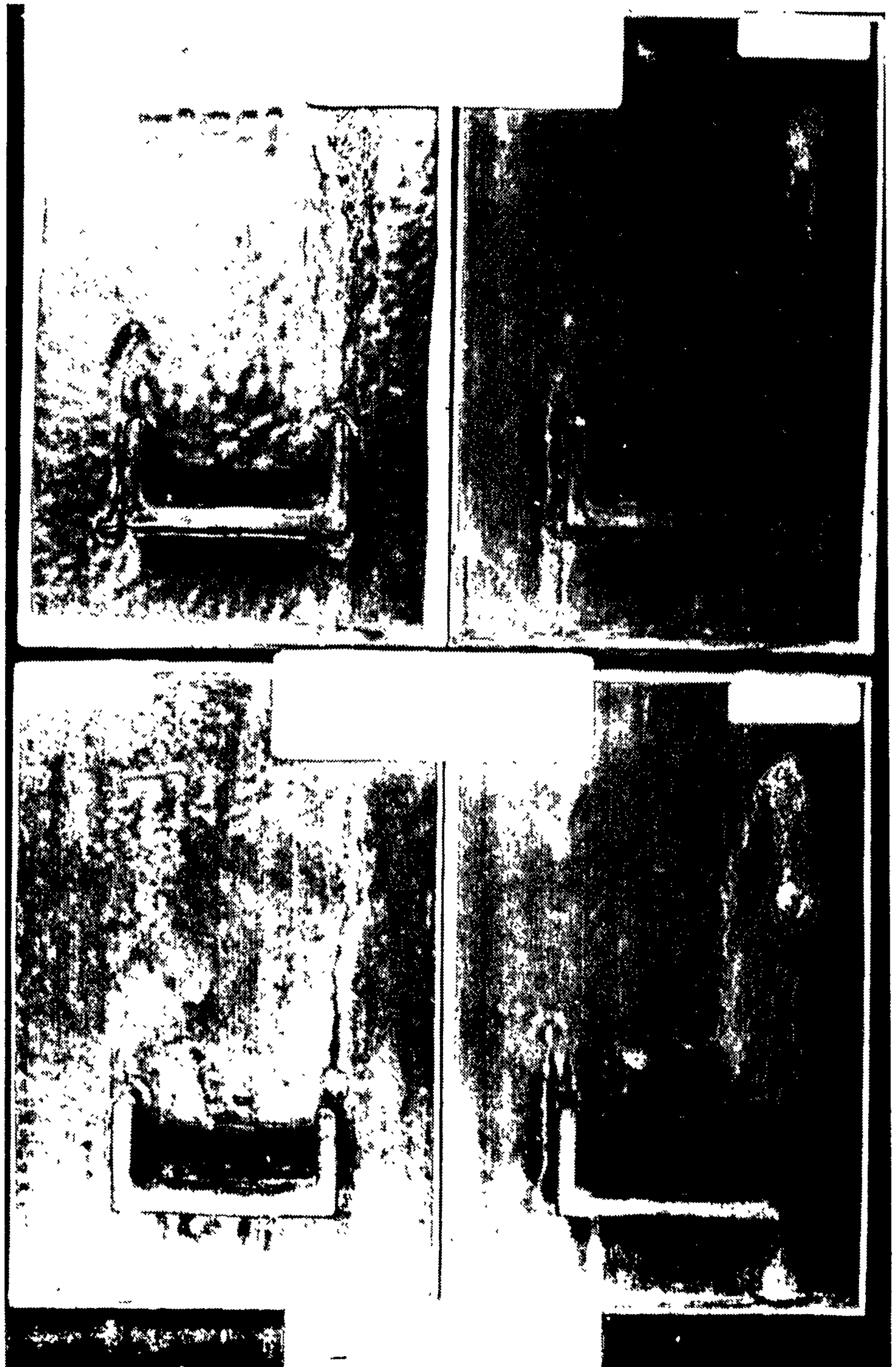


Figure 2.10. Abrasive Blast [illegible] Citric Acid Cleaned

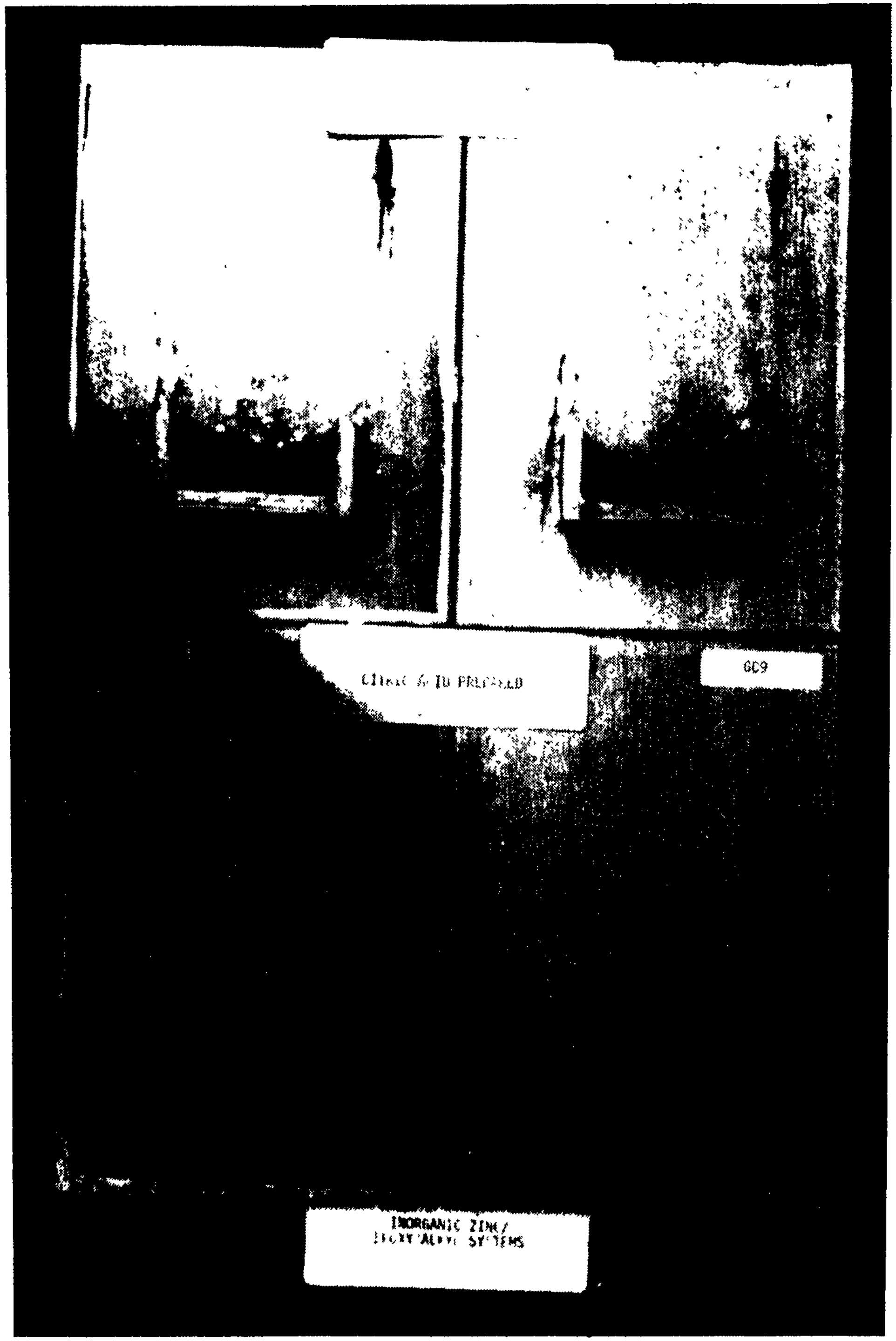
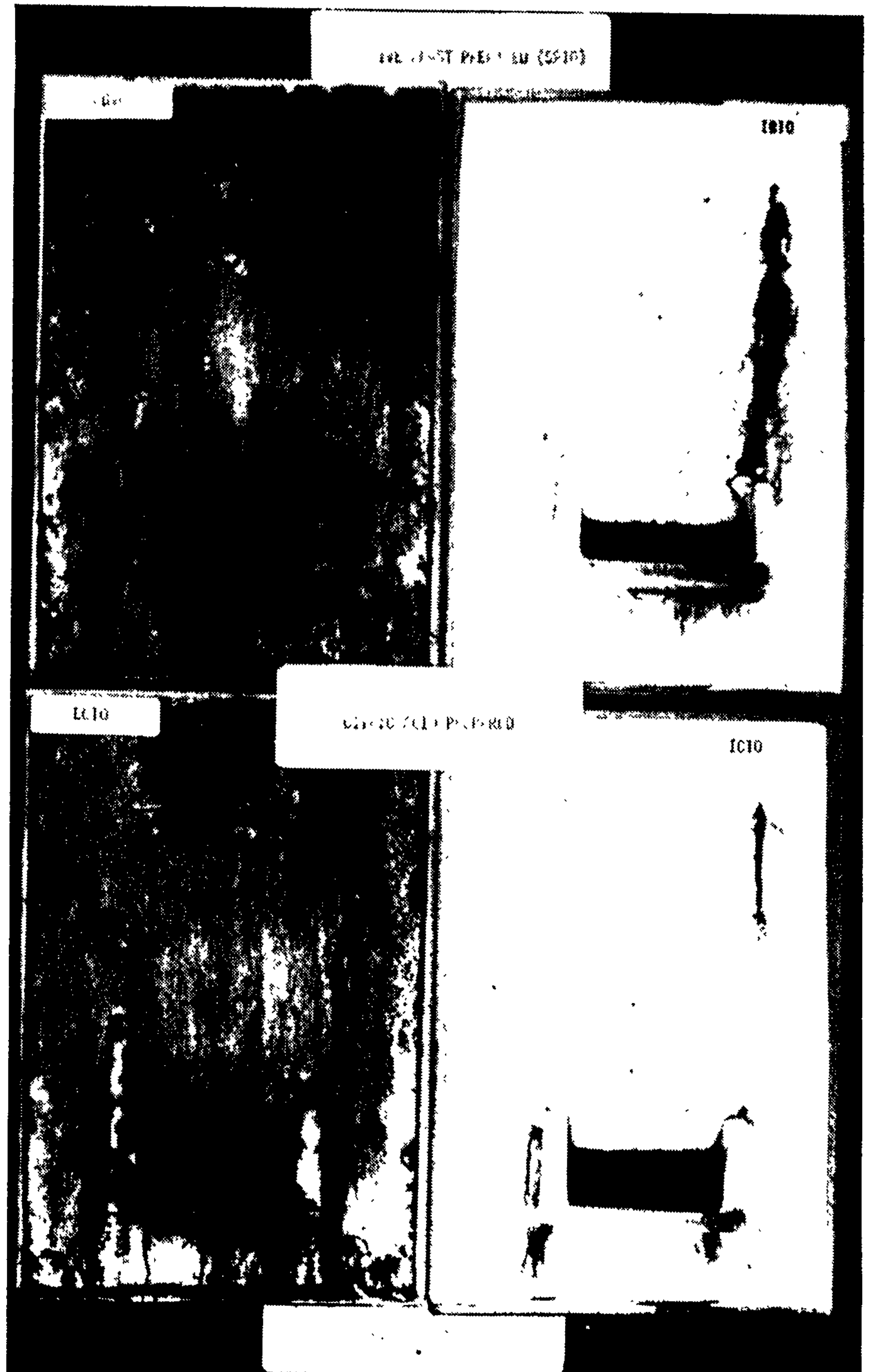
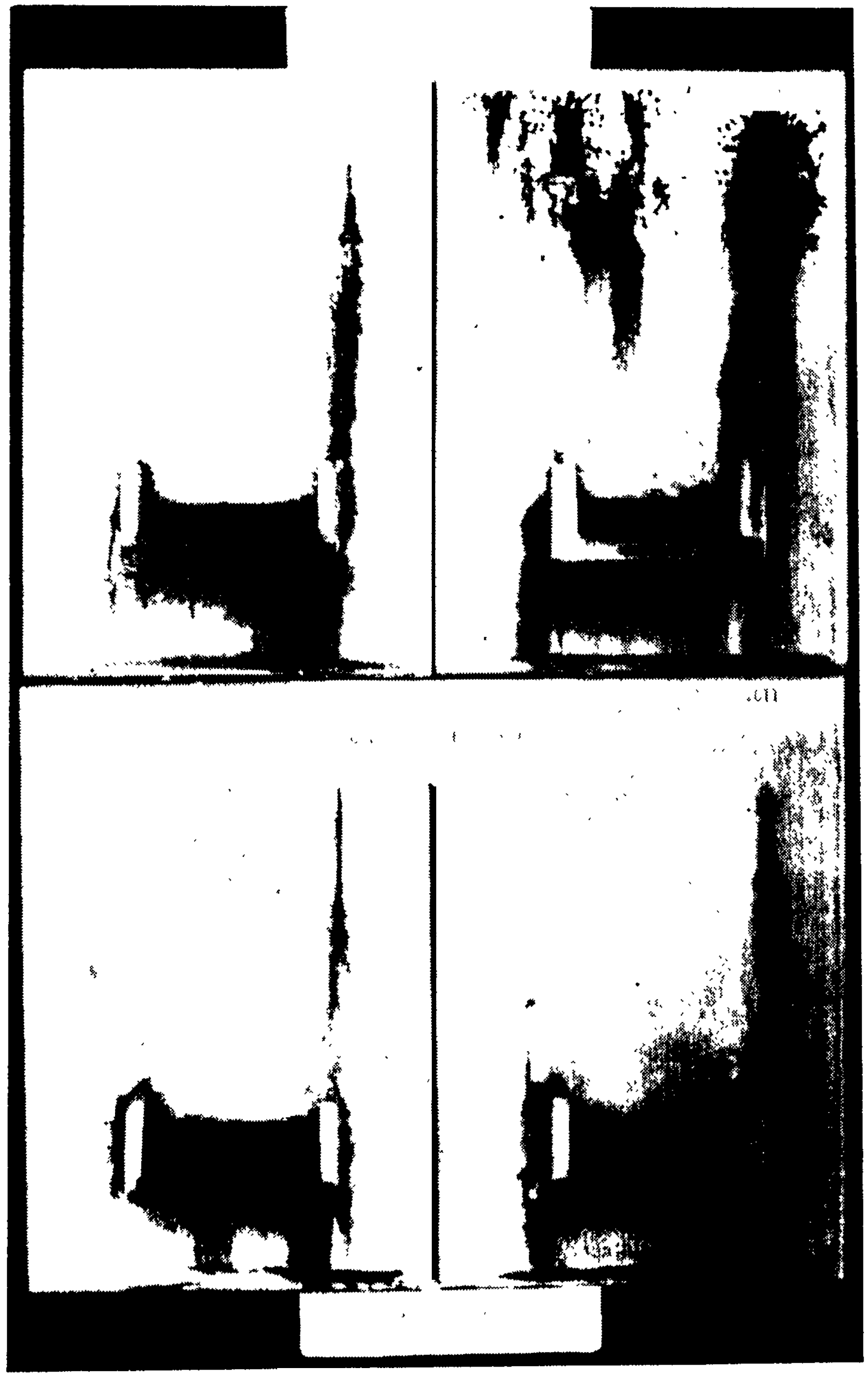


Figure 2.20: Abrasive Blast versus Citric Acid Cleaned Salt Spray Resistance of Inorganic Zinc, Epoxy, Alkyd Paint Systems


ICIO



F· gure 2.22: Abrasive Blast versus Citric Acid Cleaned
Salt Spray Resistance of Viny˙ Paint Systems

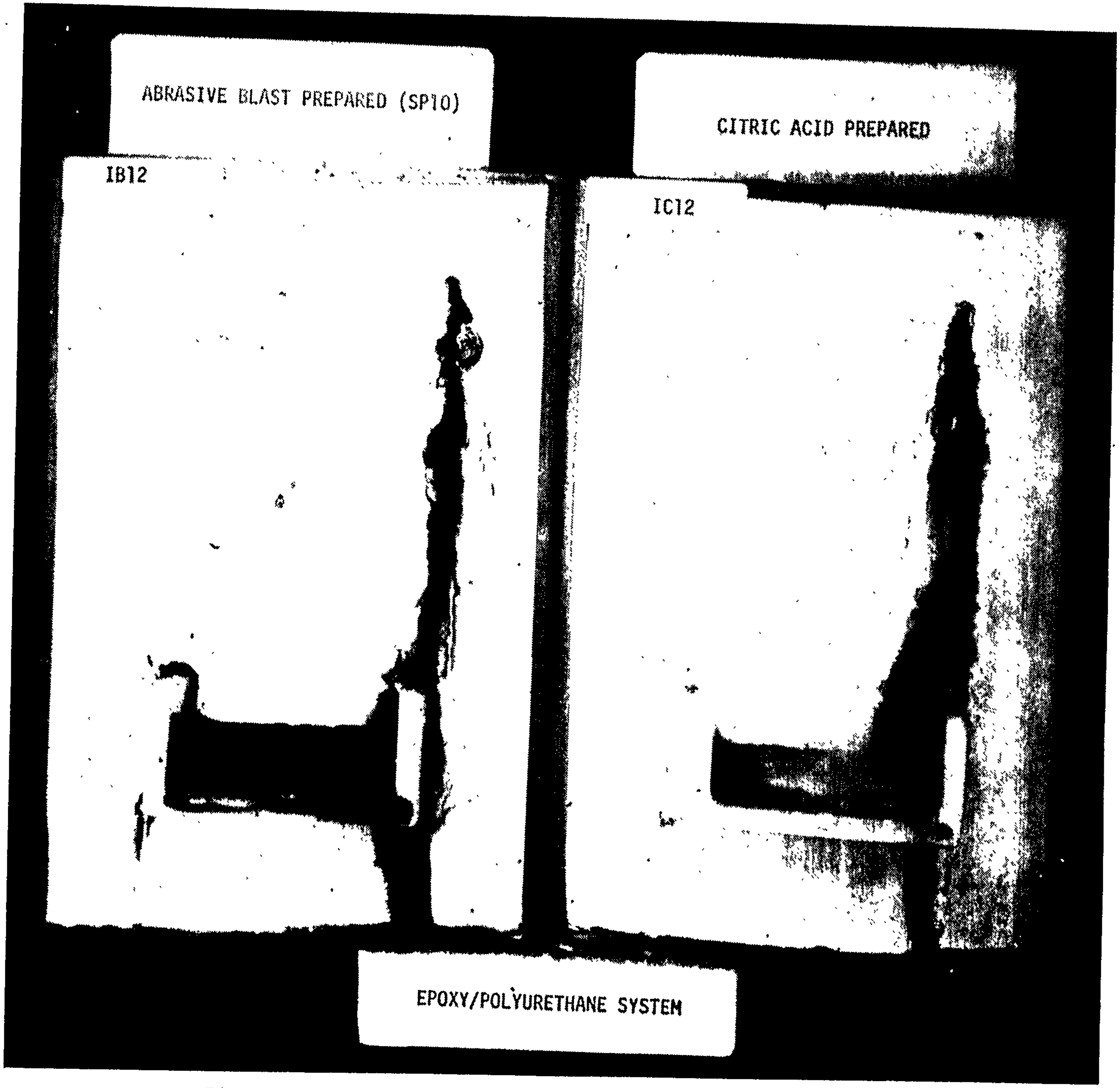


Figure 2.23: Abrasive Blast versus Citric Acid Cleaned

The most significant point is that within each generic category, the citric acid performed equal to or better than abrasive blasting. Two cases which deserve further discussion are the inorganic zinc/vinyl and alkyd systems. With the inorganic zinc/vinyl systems tested (4), the average performance of the citric acid prepared panels was 8.75, whereas the abrasive blasted performance was 8. With the alkyd systems (4), the average citric acid performance was 5 and the abrasive blasted was 2.75.

2.5.2 Aged Adhesion Tests

This test series was designed to investigate aged adhesion on all marine applications other than immersion, Three paint systems from three suppliers were randomly selected. Each of these systems was applied to ten panels (3″ X 9“) which had been prepared using citric acid and to ten panels (3″ X 9“) which had been prepared by abrasive blasting. All panels were initially abrasive blasted and allowed to rust prior to the final cleaning operation. The coated panels were then allowed to cure seven days in the laboratory. Two panels from each set were then tested for adhesion. The remaining panels were placed in a “\Jeather-Ometer” and tested for aged adhesion properties after intervals of 500 hours, 750 hours, 1000 hours and 1250 hours of exposure. This test simulated/accelerated “exterior exposed to weather” performance.

The adhesion test methods selected were the “Button Pull-Off” test using an “ElcometerAdhesion Tester” (See Figure 2.24) and a bend test over a 3/4″ mandrel (See Figure 2.25). The Button Pull-Off test is a direct measurement of the force necessary to physically remove the coating from the substrate. The value measured is expressed in pounds per square inch. The bend test is a pass/fail test without numerical quanification. This test is also used to measure flexibility.

Table II is a tabulation of Button Pull-Off adhesion values, and Table III is a tabulation of bend test results. Figures 2.27 through 2.31 are photographs of the bend test results. The bend test results can be summarized as follows:

- **No difference in performance between abrasive blasted and citric** acid cleaned panels′ with inorganic zinc/vinyl paint system.

Figure 2.24: Button Pull-Off
Adhesion Test Procedure

Figure 2.25: Bend Adhesion Test Procedure

- All abrasive blasted and inorganic zinc/epoxy paint systems passed the bend test
- Two citric acid cleaned and inorganic zinc/epoxy paint systems passed the bend test and two failed the bend test
- No difference in performance between abrasive blasted and citric acid cleaned panels with epoxy paint systems

No direct correlation can be drawn from the failure of the bend test and the results of the button adhesion test (Table II), but apparently some relationship exists as shown below. Note the low adhesion values obtained with system G, one of the inorganic zinc/epoxy systems which failed the bend test, at 500 hours, 750 hours and 1250 hours, and system A, the other inorganic zinc system which failed, at 750 hours and 1000 hours. However, these low Button Pull-Off Adhesion Test valves could be the result of procedure techniques. During the cutting around the attached (glued) button to create a uniform, representative one square "inch pull area, frictional heat was generated which could degrade the normal adhesion of the coating system. It was noted that on occasion the aluminum dollies (buttons) became extremely hot during cut out.

In an effort to explain the failure of some inorganic zinc primer systems and not others, an investigation was made into possible causes. A review of laboratory notes revealed that the original "Weather-Ometer" aged adhesion test was performed using some citric acid panels which had flash rusted prior to paint system application. Figure 2.26 is a photograph of the graded panels prior to top coating. Most of the panels used were grade 1, but some grade 2 panels were used. For this reason, System A was tested again. The button adhesion test showed no significant difference between the first test series and the second. However, the bend test demonstrated marginal performance as opposed to failure during the first test series. (See Figure 2.31). When compared to performance in the salt spray and exterior test fence, the citric acid prepared inorganic zinc primer systems (See Table I) performed equal to or better than the abrasive blast inorganic zinc primer systems.

In summary, some difference in adhesion between certain inorganic zincs/citric acid prepared and inorganic zinc abrasive blast prepared panels does exist. This difference could be attributed to a variance in mechanical adhesion due to profile and not

TABLE II: Button Pull-Off
Adhesion Test of Aged Panels

PAINT SYSTEM	SEVEN DAY CURE (LAB)		500 HR WEATHER-OMETER		750 HR WEATHER-OMETER		1000 HR WEATHER OMETER		1250 HR WEATHER-OMETER	
	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID
	350	300	100	200	200	175	300	225	200	225
INORGANIC	300	350	200	250	200	200	250	300	200	200
ZINC	300	300	100	225	200	200	250	300	250	225
VINYL	300	300	150	175	200	200	200	200	200	225
SYSTEM CODES JB2&JC2	300	200	200	225	200	300	250	225	200	200
(FIGURE 2.27)	250	250	225	225	200	225	250	300	250	200
MEAN	(3) 300	(3) 283	(1) 163	(1) 217	(1) 200	(1) 217	(3) 250	1) 258	(2) 217	(2) 213
	250	200	225	---	100	100	200	200	210	100
INORGANIC	200	200	250	---	100	100	150	150	150	100
ZINC	200	200	200	---	100	---	150	200	150	100
EPOXY (POLYAMIDE)	---	200	---	100	---	100	---	150	---	100
SYSTEM CODES GB9&GC9	---	200	---	---	---	100	---	190	---	100
(FIGURE 2.27)	---	200	---	---	---	---	---	200	---	100
MEAN	(2) 217	(2) 200	(2) 225	(2) 100	(2) 100	(2) 100	(2) 167	2) 182	(2) 170	(2) 100
	200	200	200	200	---	225	250	200	250	200
INORGANIC	200	200	200	200	---	225	250	250	225	200
ZINC	150	200	---	200	---	300	200	200	225	200
EPOXY (POLYAMIDE)	175	200	200	250	225	300	225	250	225	400
SYSTEM CODES CB7&CC7	175	250	200	200	225	200	200	300	300	350
(FIGURE 2.28)	150	225	---	250	300	250	250	250	300	300
MEAN	(1) 175	(1) 212.5	(1) 200	(1) 217	(1) 250	(1) 250	(1) 229	1) 242	(1) 254	(1) 275
	190	---	200	210	200	100	200	100	200	200
INORGANIC	190	190	190	---	190	100	190	100	200	190
ZINC	190	---	190	---	200	---	---	100	---	190
EPOXY (POLYAMIDE)	190	200	200	200	200	100	200	150	225	200
SYSTEM CODES AB6&AC6	190	200	190	200	200	100	160	100	200	190
(FIGURE 2.28)	190	190	200	200	190	100	190	100	---	190
MEAN	(1) 190	(1) 195	(1) 195	(2) 202.5	(1) 197	(2) 100	(1) 188	2) 103	(1) 206	(2) 193

TABLE II: (cont'd.)

TABLE II: Button Pull-Off
Adhesion Test of Aged Panels

PAINT SYSTEM	SEVEN DAY CURE (LAB)		500 HR WEATHER-OMETER		750 HR WEATHER OMETER		1000 HR WEATHER OMETER		1250 HR WEATHER-OMETER	
	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID	ABRASIVE BLAST	CITRIC ACID
	180	200	200	210	100	175	200	200	225	225
INORGANIC	160	200	225	---	190	175	190	200	275	275
ZINC (MODIFIED)	175	190	190	190	175	200	---	200	275	250
EPOXY (POLYAMIDE)	200	190	---	210	100	200	---	200	225	275
SYSTEM CODES LB7&LC7	200	200	190	210	---	200	175	200	250	225
(FIGURE 2.29)	200	---	---	200	175	200	150	200	225	250
MEAN	(1) 186	(1) 196	(1) 201	(1) 204	(1) 148	(1) 191	(1) 179	(1) 200	(1) 246	(1) 250
	200	210	225	300	200	250	200	250	250	250
	200	200	225	375	210	200	200	225	250	300
EPOXY (POLYAMIDE)	180	210	200	275	---	225	290	300	250	300
SYSTEM CODES DB1&DC1	205	225	250	300	225	210	290	250	250	350
(FIGURE 2.29)	---	200	225	225	225	210	290	200	350	300
	190	200	210	225	250	210	200	300	300	300
MEAN	(10 195	(1) 208	(1) 223	(3) 283	(1) 222	(1) 218	(1) 245	(1)/(2)254	(1) 275	(1) 300
		375	375	---	300	300	350	300	400	400
	300	375	400	300	325	325	350	300	375	400
EPOXY (POLYAMIDE)	300	375	375	350	300	325	400	350	375	---
SYSTEM CODES CB5&CC5	300	250	300	---	400	300	400	---	400	350
(FIGURE 2.30)	350	300	300	375	300	350	400	400	400	300
	200	---	325	375	250	300	350	400	---	300
MEAN	(1) 296	(1) 335	(1) 345	(1) 350	(1) 313	(1) 317	(1) 375	(1) 350	(1) 390	(1) 350
	400	350	400	225	200	225	210	210	300	210
	400	450	225	300	200	250	200	200	300	300
EPOXY (POLYAMIDE)	300	400	200	200	200	250	210	210	200	200
SYSTEM CODES GB5&GC5	---	400	---	225	---	200	---	200	---	200
(FIGURE 2.30)	---	400	---	250	---	300	---	210	---	220
	---	400	---	200	---	225	---	210	---	200
MEAN	(1) 367	(1) 400	(1) 275	(1) 233	(1) 200	(1) 242	(1) 207	(1) 207	(1) 267	(1) 225

NOTES: (1) FAILED WITHIN PRIMER , (2) FAILED AT PRIMER/SUBSTRATE INTERFACE, (3) FAILED WITHIN MIDCOAT
(4) SEE ANNEX C FOR SYSTEM DECODING PROCEDURE.

TABLE III: Bend Test - 3/4" Mandrel
Aged Adhesion - Weather-Ometer

GENERIC PAINT SYSTEM	SYSTEM CODE	SURFACE PREPARATION	SEVEN DAY CURE	500 HR EXPOSURE	750 HR EXPOSURE	1000HR EXPOSURE	1250HR EXPOSURE	PHOTOGRAPHIC FIGURE NO.
ALKYL INORGANIC ZINC (352) VINYL WASH PRIMER (1799) VINYL (VC37)	JB2	Abrasive Blast	Passed	Passed	Passed	Passed	Passed	2.27
	JC2	Citric Acid	Passed	Passed	Passed	Passed	Passed	2.27
ALKYL INORGANIC ZINC (13F12 POLAMIDE EPOXY (89F15)	GB9*	Abrasive Blast	Passed	Passed	Passed	Passed	Passed	2.27
	GC9*	Citric Acid	Passed	Failed at Substrate	Failed at Substrate	Failed at Substrate	Failed at Substrate	2.27
ALKYL INORGANIC ZINC (CZ11) POLYAMIDE EPOXY (190HB)	CB7	Abrasive Blast	Passed	Passed	Passed	Passed	Passed	2.28
	CC7	Citric Acid	Passed	Passed	Passed	Passed	Passed	2.28
ALKYL INORGANIC ZINC (D-9) POLYAMIDE EPOXY (383) ALIPHATIC POLYURETHANE (450	AB6	Abrasive Blast	Passed	Passed	Passed	Passed	Passed	2.28
	AC6	Citric Acid	Passed	Failed at Substrate	Failed at Substrate	Failed at Substrate	Failed at Substrate	2.28
MODIFIED INORGANIC ZINC(302 POLYAMIDE EPOXY (224) ACRYLIC MODIFIED EPOXY (239	LB7	Abrasive Blast	Passed	Failed at Substrate	Passed	Marginal	Passed	2.29
	LC7	Citric Acid	Passed	Passed	Passed	Failed at Substrate	Passed	2.29
POLYAMIDE EPOXY (201) POLYAMIDE EPOXY (224) ACRYLIC MODIFIED EPOXY (239	DB1	Abrasive Blast	Passed	Passed	Passed	Passed	Passed	2.29
	DC1	Citric Acid	Passed	Passed	Passed	Passed	Passed	2.29
POLYAMIDE EPOXY (193) POLYAMIDE EPOXY (190HB)	CB5	Abrasive Blast	Passed	Passed	Passed	Passed	Passed	2.30
	CC5	Citric Acid	Passed	Passed	Passed	Passed	Passed	2.30
POLYAMIDE EPOXY (89F15) POLYAMIDE EPOXY (89F15)	GB5	Abrasive Blast	Passed	Passed	Passed	Passed	Passed	2.30
	GC5	Citric Acid	Passed	Passed	Passed	Passed	Passed	2.30

* SAME AS SALT FOG EXCEPT TOPCOAT OF ALKYD NOT APPLIED

NOTE: SEE ANNEX C FOR SYSTEM DECODING PROCEDURE

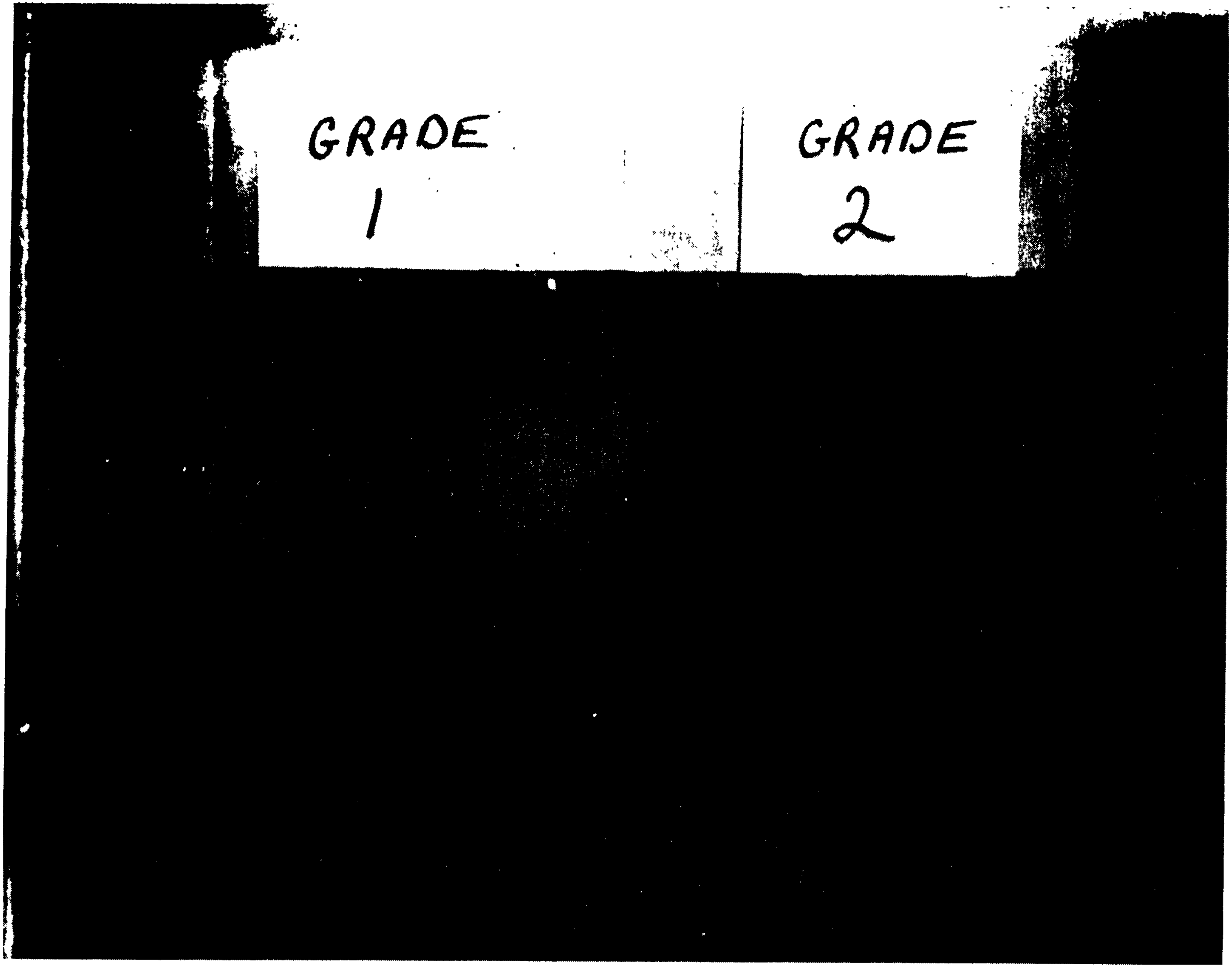


Figure 2.26: Surface Preparation Grading Procedure
for First Weather-Ometer Aged Adhesion Series

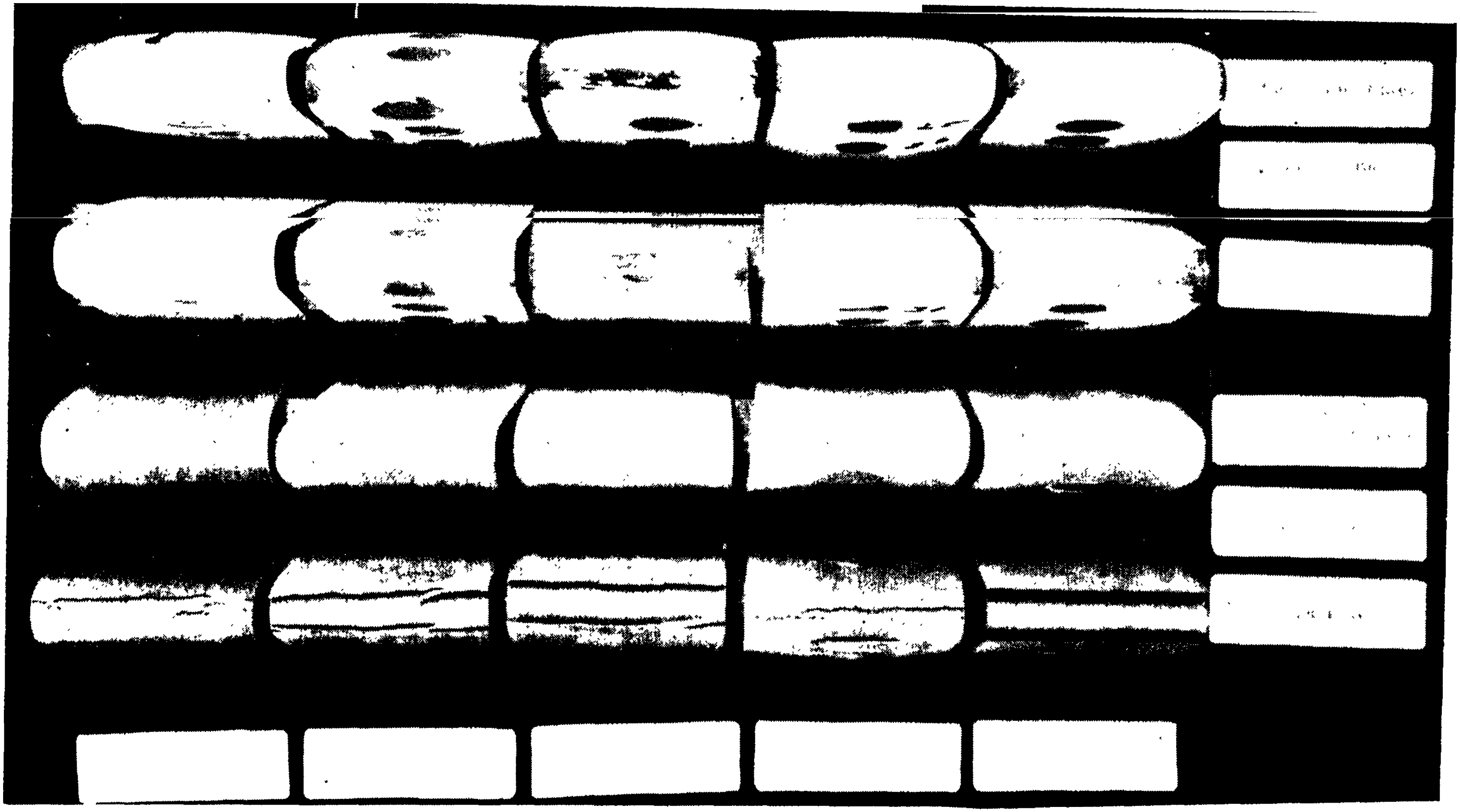


Figure 2.27: Results of Bend Test - Inorganic Zinc Vinvl Svstem and Inorganic Zinc Epoxv Svstem

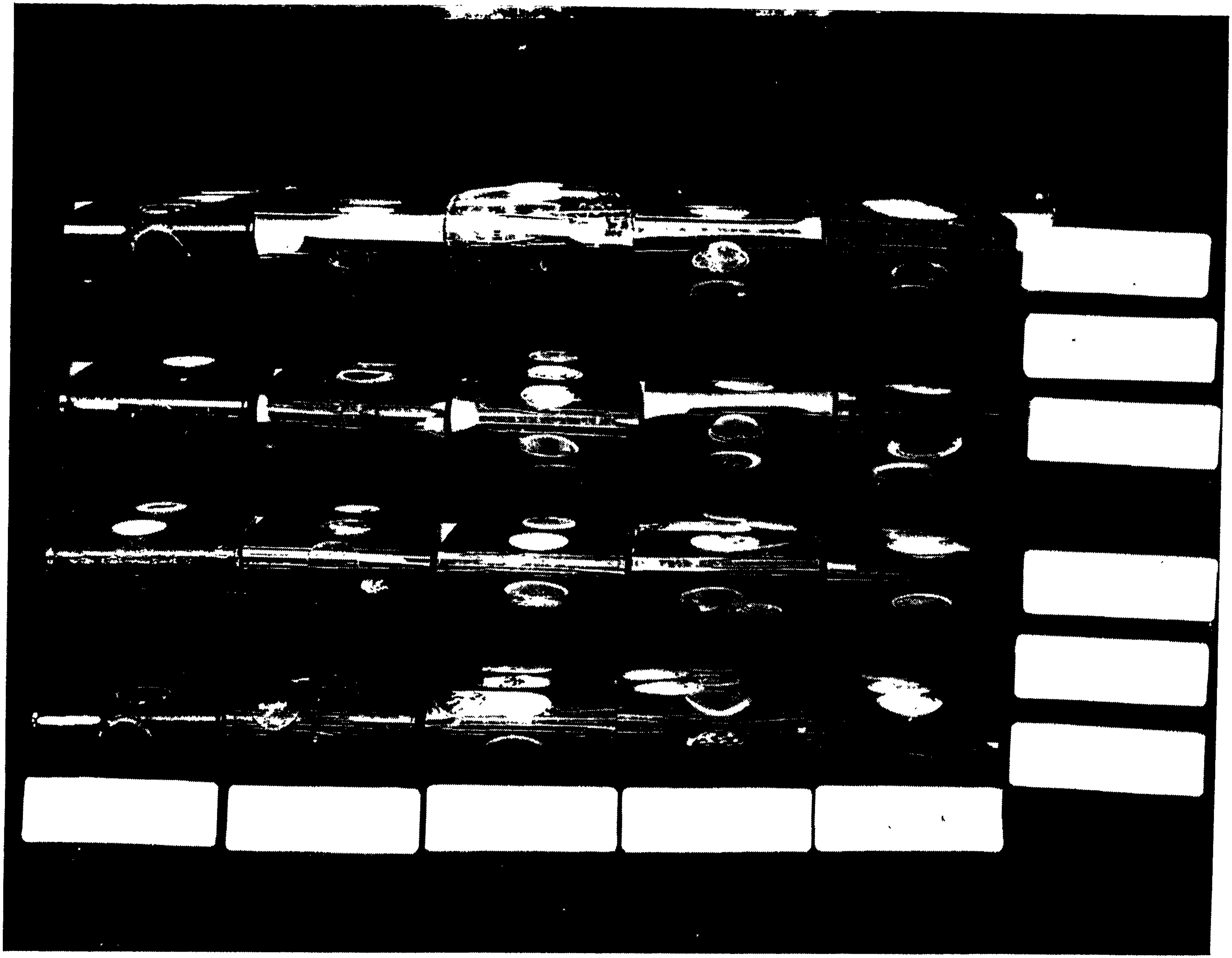
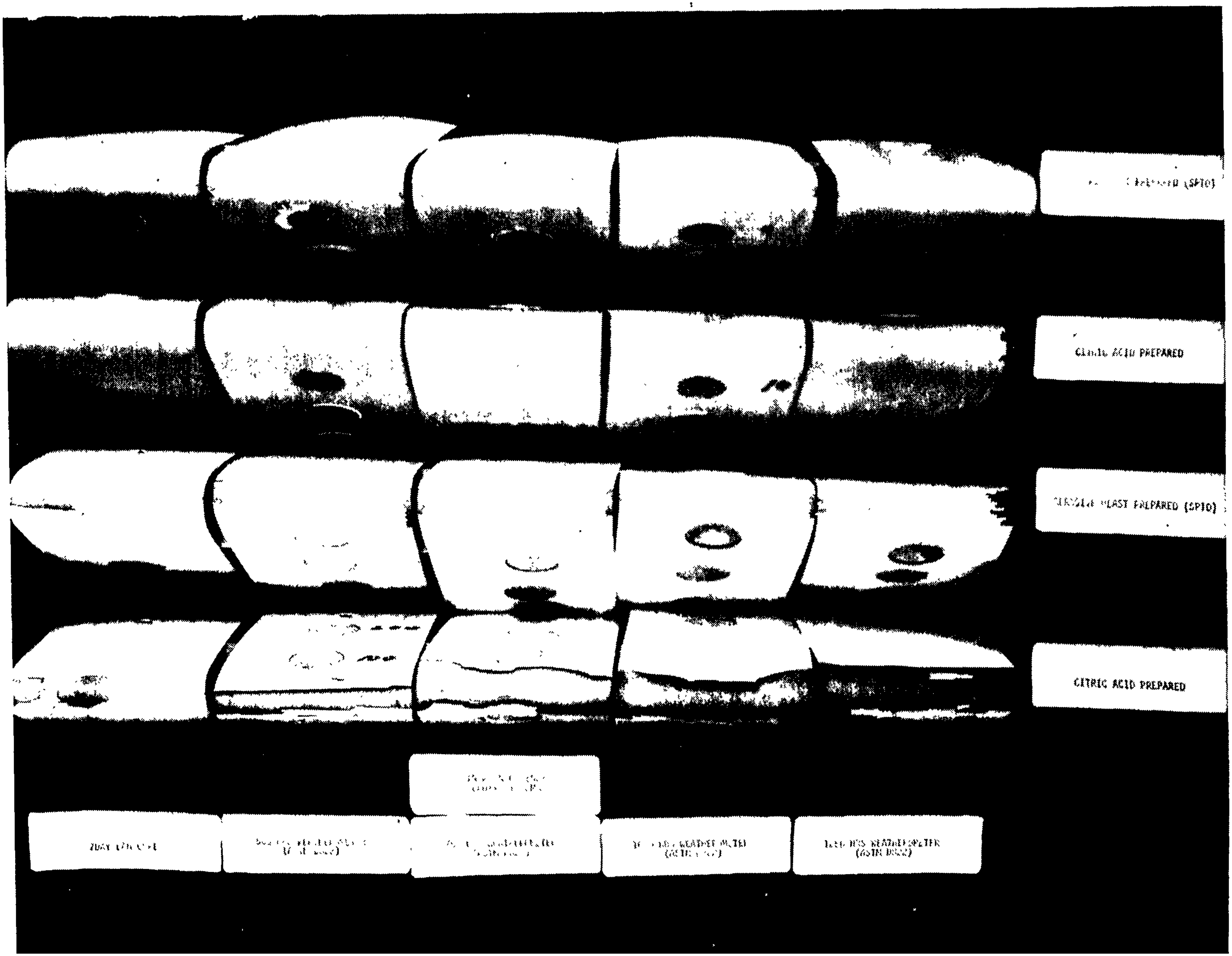


Figure 2.29: Results of Bend Test - Inorganic Zinc
Epoxy and Epoxy System


CITRIC ACID PREPARED

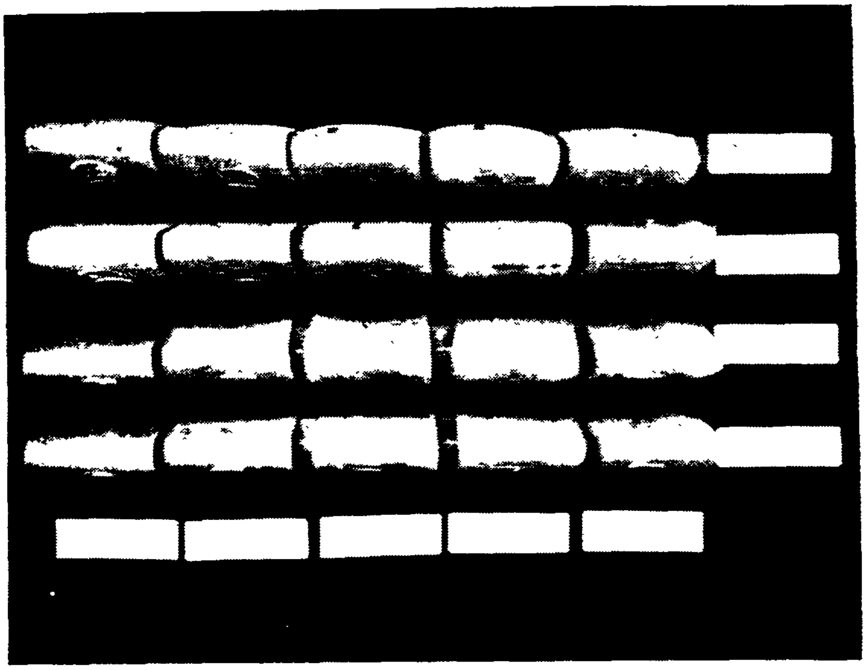


Figure 2.30: Results of Bend Test - Epoxy Systems

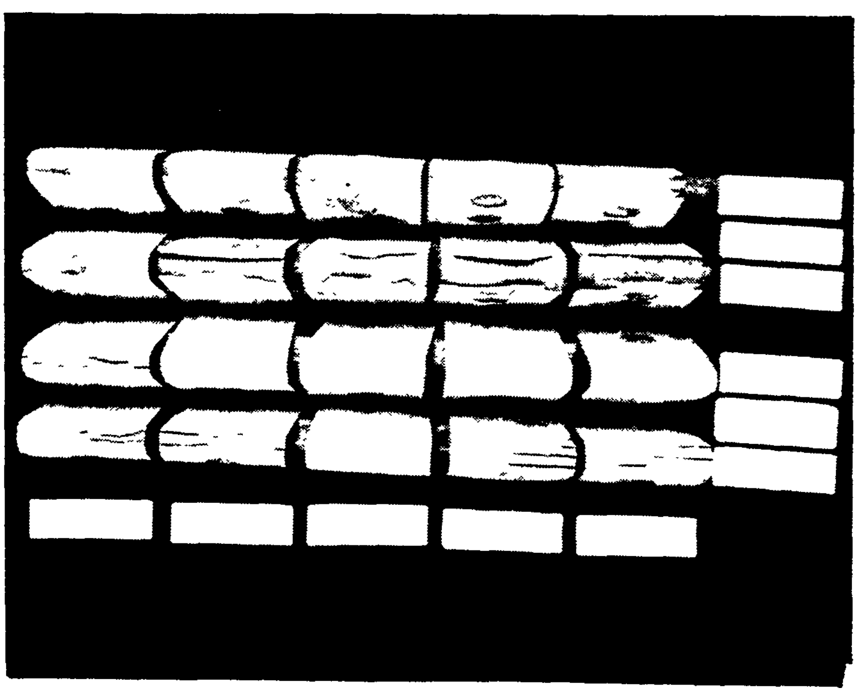


Figure 2.31: Results of Bend Test - System AB1/AC1 Retested

incompatibility with the chemical nature of the substrate. Annex A contains a discussion of the profile differences between abrasive blasted steel and citric acid cleaned steel.

2.5.3 Exterior Exposure Tests

There were two different series of exterior test fence exposures of primers in a marine environment. The first was a direct comparison of primers applied to both citric acid cleaned panels and abrasive blast cleaned panels. The second was a test to compare citric acid as a touch-up surface preparation technique to the widely used power tool cleaning touch-up technique. The paragraphs which follow discuss each series in detail.

2.5.3.1 Various Generic Primers Applied to Both Citric Acid and Abrasive Blast Cleaned Steel Test Panels.

One hundred primers representing seventeen generic types were selected from ten suppliers. Test panels of A-36 steel measuring 6“ X 18” were first descaled and then allowed to rust for approximately eight weeks by exposure in an outside industrial; marine environment. Following aged rusting, the panels were divided into two groups. The first group was abrasive blasted to Steel Structures surface preparation “Near White Blast”, SP10, and the second group was cleaned utilizing a citric acid process. Each of the selected primers was then applied to a panel cleaned by each process. Both panels were sprayed at the same time in an effort to duplicate film thicknesses. The resulting primed panels were then placed on the test fence at 45° South for nine months. Rust grades were determined in accordance with ASTM D61O. The results of this exposure test are summarized in Table IV. Again a statistical analysis was made of the average performance of all abrasive blast compared to all citric acid panels. The average performance of the primers applied over abrasive blasted surfaces was inferior to the performance of those applied over citric acid. The mean performance of abrasive blast was 8.2, and the mean for citric acid was 8 .59. Figures 2.32 through 2.37 are photographs comparing the performance of some of these primers.

TABLE IV: Exterior Test Fence Performance of Various Generic Primers Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Panels

GENERIC TYPE	SUPPLIER	PRODUCT NO.	SURFACE PREPARATION	FILM THICKNESS (MILS)	NINE MONTH PERFORMANCE RATIN
Alkyl Inorganic Zinc, Solvent Base	Ameron	D-9	Abrasive Blast	4.8	9
			Citric Acid	4.8	9
Alkyl Inorganic Zinc, Solvent Base	Byco	101	Abrasive Blast	2.8	9
			Citric Acid	2.4	9
Alkyl Inorganic Zinc, Solvent Base	Carboline	CZ11	Abrasive Blast	4.2	10
			Citric Acid	4.2	10
Alkyl Inorganic Zinc, Solvent Base	Carboline	CW11	Abrasive Blast	1.6	9
			Citric Acid	1.4	9
Alkyl Inorganic Zinc, Solvent Base	Devoe	304	Abrasive Blast	2.6	9
			Citric Acid	2.6	9
Alkyl Inorganic Zinc, Solvent Base	Farboil	114	Abrasive Blast	3.0	9
			Citric Acid	2.7	9
Alkyl Inorganic Zinc, Solvent Base	Imperial	555	Abrasive Blast	3.0	9
			Citric Acid	2.7	9
Alkyl Inorganic Zinc, Solvent Base	International	QHA027/ QHA028	Abrasive Blast	4.6	9
			Citric Acid	4.7	9
Alkyl Inorganic Zinc, Solvent Base	Mobil	13F12	Abrasive Blast	1.8	9
			Citric Acid	1.6	9
Alkyl Inorganic Zinc, Solvent Base	Napko	1375	Abrasive Blast	4.1	9
			Citric Acid	4.2	9
Alkyl Inorganic Zinc, Solvent Base	Porter	351	Abrasive Blast	2.2	9
			Citric Acid	2.1	9
Modified Alkyl Inorganic Zinc	Devoe	302R	Abrasive Blast	3.2	9
			Citric Acid	3.0	9
One Component Inorganic Zinc	Ameron	160	Abrasive Blast	3.2	9
			Citric Acid	3.2	9
One Component Inorganic Zinc	Ameron	2155	Abrasive Blast	4.1	9
			Citric Acid	3.6	9
One Component Inorganic Zinc	Byco	102SP92	Abrasive Blast	6.8	9
			Citric Acid	6.5	9
One Component Inorganic Zinc	Devoe	306	Abrasive Blast	3.8	8
			Citric Acid	4.0	9
One Component Inorganic Zinc	Devoe	308	Abrasive Blast	1.7	6
			Citric Acid	1.4	9
One Component Inorganic Zinc	Devoe	309	Abrasive Blast	2.6	9
			Citric Acid	2.0	9
One Component Inorganic Zinc	Imperial	545	Abrasive Blast	5.1	9
			Citric Acid	3.6	9
One Component Inorganic Zinc	International	NQA200	Abrasive Blast	3.1	8
			Citric Acid	3.0	10
One Component Inorganic Zinc	Mobil	13G10	Abrasive Blast	2.9	9
			Citric Acid	2.4	9
One Component Inorganic Zinc	Napko	1301	Abrasive Blast	6.0	9
			Citric Acid	5.4	9
Water Based, Self Cure, Inorganic Zinc	Ameron	D-4	Abrasive Blast	4.1	9
			Citric Acid	4.1	9
Water Based, Self Cure, Inorganic Zinc	Devoe	305	Abrasive Blast	4.3	9
			Citric Acid	3.5	9
Water Based, Self Cure, Inorganic Zinc	Farboil	76	Abrasive Blast	5.0	9
			Citric Acid	4.5	9

TABLE IV: (cont'd.)

TABLE IV: Exterior Test Fence Performance of Various Generic Primers Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Panels

GENERIC TYPE	SUPPLIER	PRODUCT NO.	SURFACE PREPARATION	FILM THICKNESS (MILS)	NINE MONTH PERFORMANCE RATING
Water Based, Self Cure, Inorganic Zinc	International	TQA001/ TQA002	Abrasive Blast	3.1	9
			Citric Acid	3.0	9
Water Based, Self Cure, Inorganic Zinc	Mobil	46F1	Abrasive Blast	4.3	1
			Citric Acid	3.8	6
Water Based, Self Cure, Inorganic Zinc	Napko	1371	Abrasive Blast	5.1	9
			Citric Acid	5.3	9
Post Cure, Inorganic Zinc	Ameron	D-3	Abrasive Blast	4.6	10
			Citric Acid	4.3	10
Post Cure, Inorganic Zinc	Napko	1361	Abrasive Blast	3.3	10
			Citric Acid	3.1	10
One Component Epoxy Zinc Rich	Byco	150-1	Abrasive Blast	4.1	9
			Citric Acid	3.6	9
One Component Epoxy Zinc Rich	Imperial	512	Abrasive Blast	3.6	9
			Citric Acid	2.9	9
One Component Epoxy Zinc Rich	International	ETA441	Abrasive Blast	3.0	1
			Citric Acid	2.8	5
One Component Epoxy Zinc Rich	Mobil	518F208	Abrasive Blast	4.0	9
			Citric Acid	2.9	9
One Component Epoxy Zinc Rich	Napko	1355	Abrasive Blast	9.4	9
			Citric Acid	9.2	9
One Component Epoxy Zinc Rich	Porter	309	Abrasive Blast	3.4	9
			Citric Acid	3.3	9
Two Component Epoxy Zinc Rich	Byco	150-5	Abrasive Blast	4.5	9
			Citric Acid	4.3	9
Two Component Epoxy Zinc Rich	Farboil	28	Abrasive Blast	2.4	8
			Citric Acid	2.3	8
Two Component Epoxy Zinc Rich	Mobil	13F4	Abrasive Blast	2.4	8
			Citric Acid	2.3	9
Two Component Epoxy Zinc Rich	Napko	5614	Abrasive Blast	5.5	9
			Citric Acid	5.4	9
Two Component Epoxy Zinc Rich	Porter	308	Abrasive Blast	3.8	9
			Citric Acid	3.6	9
Organic Zinc, Chlorinated Rubber	Byco	150-7	Abrasive Blast	3.7	9
			Citric Acid	3.7	9
Organic Zinc	Farboil	79 (Mil-P-1048)	Abrasive Blast	3.9	9
			Citric Acid	3.9	9
One Component Epoxy Primer	Ameron	185	Abrasive Blast	2.9	9
			Citric Acid	2.7	9
One Component Epoxy Primer	Byco	150-2	Abrasive Blast	1.7	4 Fig. (2.36)
			Citric Acid	1.2	4 Fig. (2.36)
One Component Epoxy Primer	Farboil	1E2546	Abrasive Blast	1.7	1 Fig. (2.33)
			Citric Acid	1.3	1 Fig. (2.33)
One Component Epoxy Primer	Imperial	1215	Abrasive Blast	2.3	6
			Citric Acid	1.9	7
One Component Epoxy Primer	International	NEA200	Abrasive Blast	2.8	9
			Citric Acid	2.6	9
One Component Epoxy Primer	Napko	1340	Abrasive Blast	2.6	10
			Citric Acid	2.6	10
Polyamide Epoxy	Ameron	71	Abrasive Blast	3.2	8
			Citric Acid	2.9	9

TABLE IV: (cont'd.)

TABLE IV: Exterior Test Fence Performance of Various Generic Primers Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Panels

GENERIC TYPE	SUPPLIER	PRODUCT NO.	SURFACE PREPARATION	FILM THICKNESS (MILS)	NINE MONTH PERFORMANCE RATING
Polyamide Epoxy	Carboline	193	Abrasive Blast	4.0	7
			Citric Acid	3.8	8
Polyamide Epoxy	Devoe	202	Abrasive Blast	2.0	8
			Citric Acid	2.2	9
Polyamide Epoxy	Devoe	208	Abrasive Blast	2.1	7
			Citric Acid	1.8	8
Polyamide Epoxy	Devoe	230FD	Abrasive Blast	6.1	10
			Citric Acid	5.4	10
Polyamide Epoxy	Farboil	4202	Abrasive Blast	2.0	4
			Citric Acid	1.8	6
Polyamide Epoxy	Farboil	NAVY For. 150	Abrasive Blast	3.9	10
			Citric Acid	3.4	10
Polyamide Epoxy	Imperial	1219	Abrasive Blast	5.7	8
			Citric Acid	5.3	9
Polyamide Epoxy	International	EPA0061/ EBA744	Abrasive Blast	3.9	10
			Citric Acid	3.7	10
Polyamide Epoxy	Mobil	65T1/ 65F15B	Abrasive Blast	4.0	10
			Citric Acid	3.6	10
Polyamide Epoxy	Napko	5616	Abrasive Blast	2.0	10
			Citric Acid	2.2	10
Polyamide Epoxy	Porter	4300 MCR43	Abrasive Blast	2.2	10
			Citric Acid	2.4	10
Polyamide Epoxy	Porter	24770	Abrasive Blast	2.5	7
			Citric Acid	2.8	9
Polyamine Epoxy	Ameron	2156	Abrasive Blast	4.9	9
			Citric Acid	5.4	9
Polyamine Epoxy	Byco	E-Prime 60	Abrasive Blast	6.8	10
			Citric Acid	5.8	10
Polyamine Epoxy	Carboline	187HFP	Abrasive Blast	7.0	10
			Citric Acid	7.6	10
Polyamine Epoxy	Mobil	71F84B/ 71T1	Abrasive Blast	2.6	7
			Citric Acid	2.7	7
Polyamine Epoxy	Mobil	264F25/ 264T24	Abrasive Blast	3.9	10
			Citric Acid	3.9	10
Polyamine Epoxy	Napko	5628	Abrasive Blast	3.5	10
			Citric Acid	3.5	10
Polyamine Epoxy	Porter	7650	Abrasive Blast	2.0	6 Fig. (2.34
			Citric Acid	1.8	7 Fig. (2.34
Epoxy Ester	Byco	360-1	Abrasive Blast	3.2	9
			Citric Acid	3.1	9
Epoxy Ester	Farboil	8229	Abrasive Blast	1.8	8
			Citric Acid	2.2	9
Alkyd	Byco	400-2	Abrasive Blast	2.5	8
			Citric Acid	2.5	9
Alkyd	Farboil	1253	Abrasive Blast	3.3	10
			Citric Acid	3.0	10
Alkyd	Farboil	6031	Abrasive Blast	2.3	8
			Citric Acid	2.1	9
Alkyd	Imperial	62	Abrasive Blast	2.9	9
			Citric Acid	2.7	9

TABLE IV: (cont'd.)

TABLE IV: Exterior Test Fence Performance of Various Generic Primers Applied to Either Abrasive Blast Cleaned or Citric Acid Cleaned Panels

GENERIC TYPE	SUPPLIER	PRODUCT NO.	SURFACE PREPARATION	FILM THICKNESS (MILS)	NINE MONTH PERFORMANCE RATING
Alkyd	International	CPA476	Abrasive Blast	2.4	8
			Citric Acid	2.2	8
Alkyd	Mobil	53R1	Abrasive Blast	2.8	9
			Citric Acid	2.8	9
Alkyd	Napko	1313	Abrasive Blast	2.7	8
			Citric Acid	3.0	9
Alkyd	Porter	297	Abrasive Blast	2.5	9
			Citric Acid	2.6	9
Vinyl	Ameron	86	Abrasive Blast	1.6	4 Fig. (2.32)
			Citric Acid	1.0	8 Fig. (2.32)
Vinyl	Ameron	33	Abrasive Blast	2.4	4
			Citric Acid	2.0	4
Vinyl	Byco	600-2	Abrasive Blast	2.2	9
			Citric Acid	1.7	9
Vinyl	Carboline	8HB	Abrasive Blast	2.8	7
			Citric Acid	2.9	8
Vinyl	Farboil	6600S	Abrasive Blast	3.2	7
			Citric Acid	3.1	8
Vinyl	International	VXL000	Abrasive Blast	3.3	10
			Citric Acid	3.0	10
Vinyl Wash Primer	Porter	VC17	Abrasive Blast	1.2	Failed After 2 months
			Citric Acid	0.9	Failed After 2 months
Chlorinated Rubber	Carboline	3631	Abrasive Blast	2.3	8
			Citric Acid	2.4	8
Chlorinated Rubber	Devoe	MD3500	Abrasive Blast	1.7	3
			Citric Acid	1.6	2
Chlorinated Rubber	Farboil	58ACG	Abrasive Blast	1.9	7
			Citric Acid	1.6	8
Chlorinated Rubber	Imperial	880	Abrasive Blast	4.8	10
			Citric Acid	5.0	10
Chlorinated Rubber	International	LPA300	Abrasive Blast	2.8	9
			Citric Acid	2.8	9
Chlorinated Rubber	Mobil	67F34	Abrasive Blast	3.9	9
			Citric Acid	4.2	9
Chlorinated Rubber	Napko	5202	Abrasive Blast	4.2	10
			Citric Acid	4.1	10
Ketamine Epoxy	Devoe	244HS	Abrasive Blast	3.7	10
			Citric Acid	3.3	10
Bituminous	Devoe	4314	Abrasive Blast	2.5	8
			Citric Acid	2.3	8
Bituminous	International	JAA021	Abrasive Blast	3.8	10
			Citric Acid	3.6	10
Phenolic-Vinyl	International	NFA081	Abrasive Blast	2.1	10
			Citric Acid	2.1	10
Water Borne (Emulsion)	Byco	500-1	Abrasive Blast	2.4	6 Fig. (2.37)
			Citric Acid	2.1	7 Fig. (2.37)
Water Borne (Emulsion)	Farboil	8285	Abrasive Blast	3.1	7
			Citric Acid	3.1	8
			Abrasive Blast		
			Citric Acid		

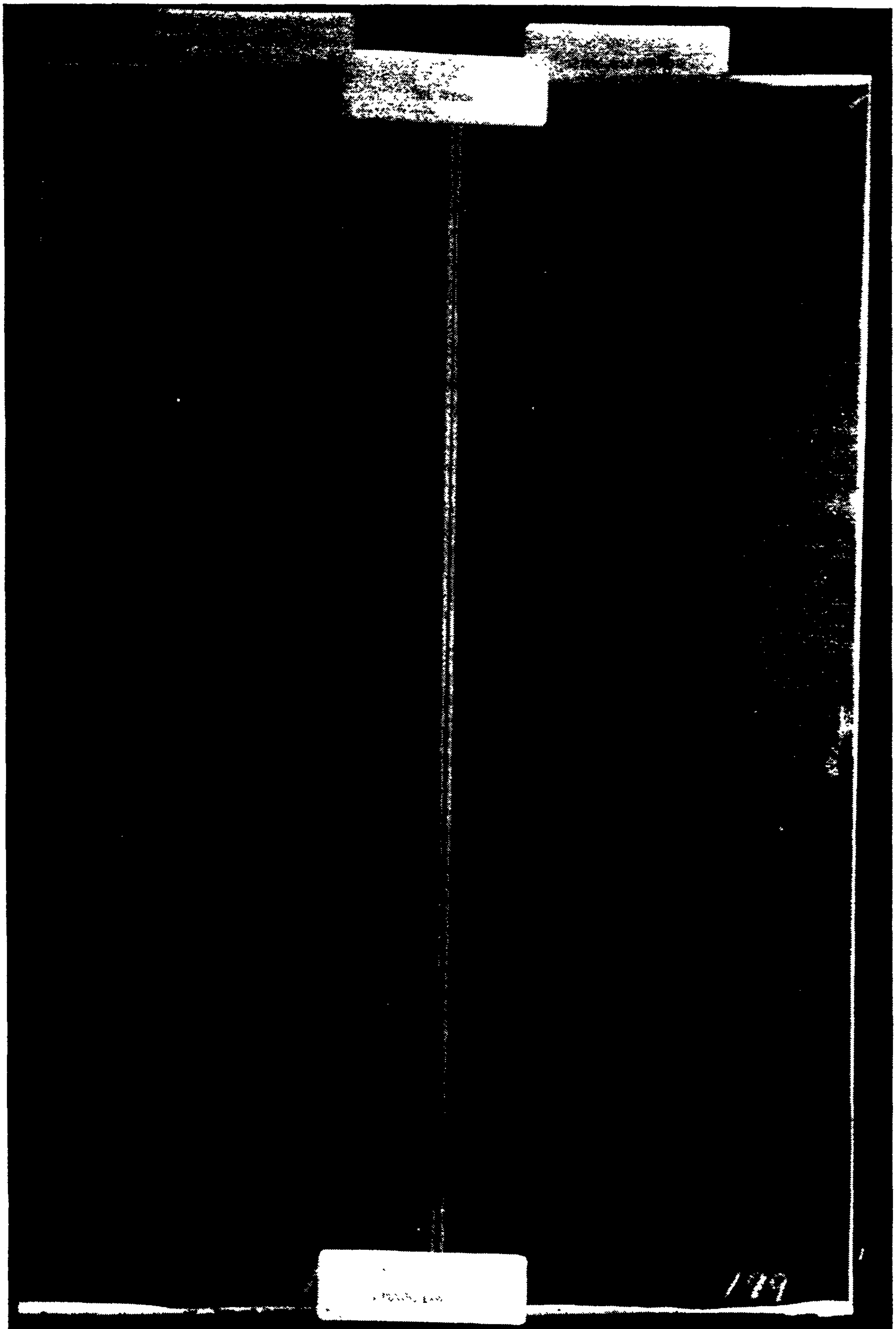


Figure 2.32: Exterior Performance Results of
Vinyl Primer After Four Months of Exposure

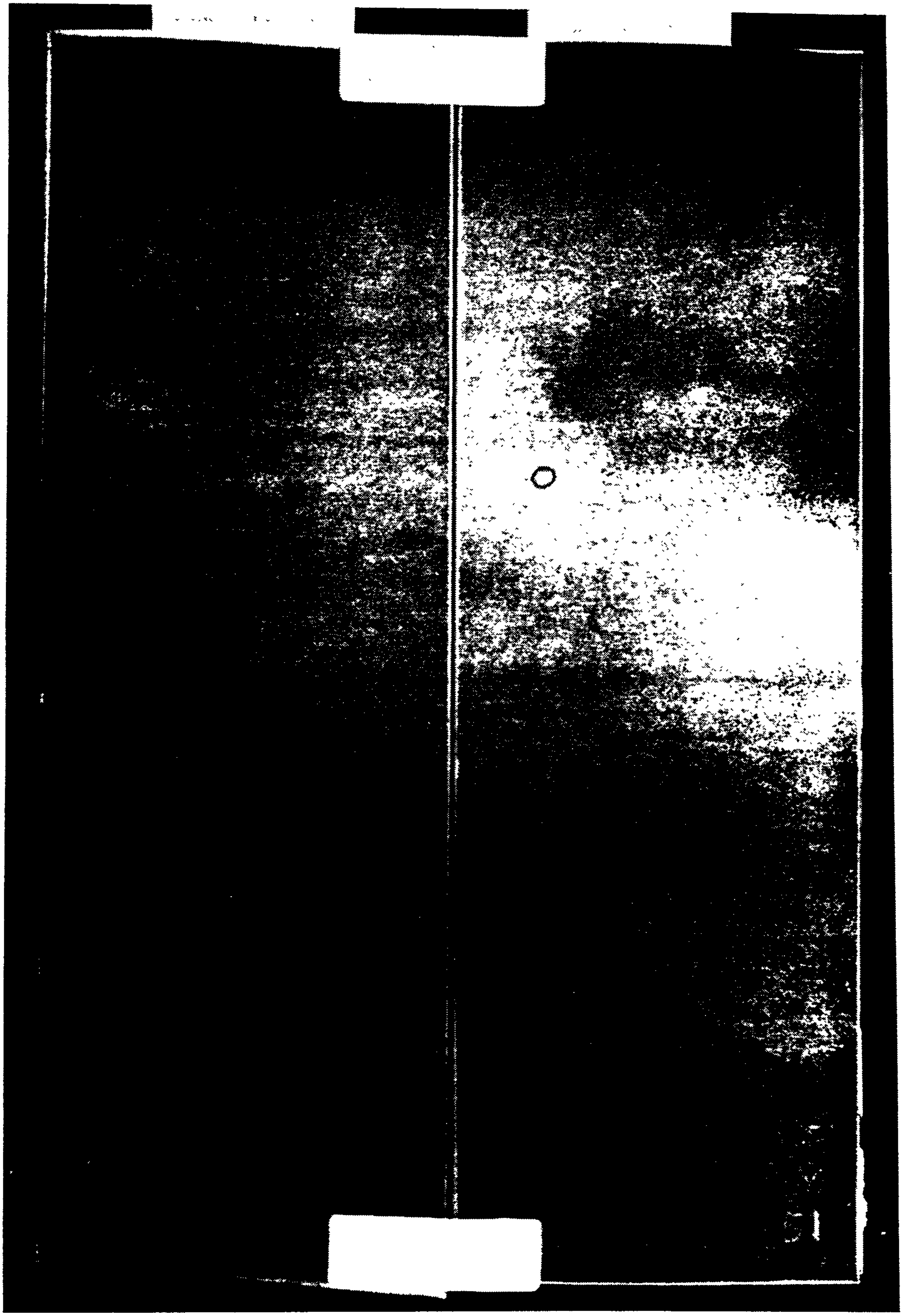


Figure 2.33: Exterior Performance Results of One Component
Epoxy Primer After Three Months of Exposure

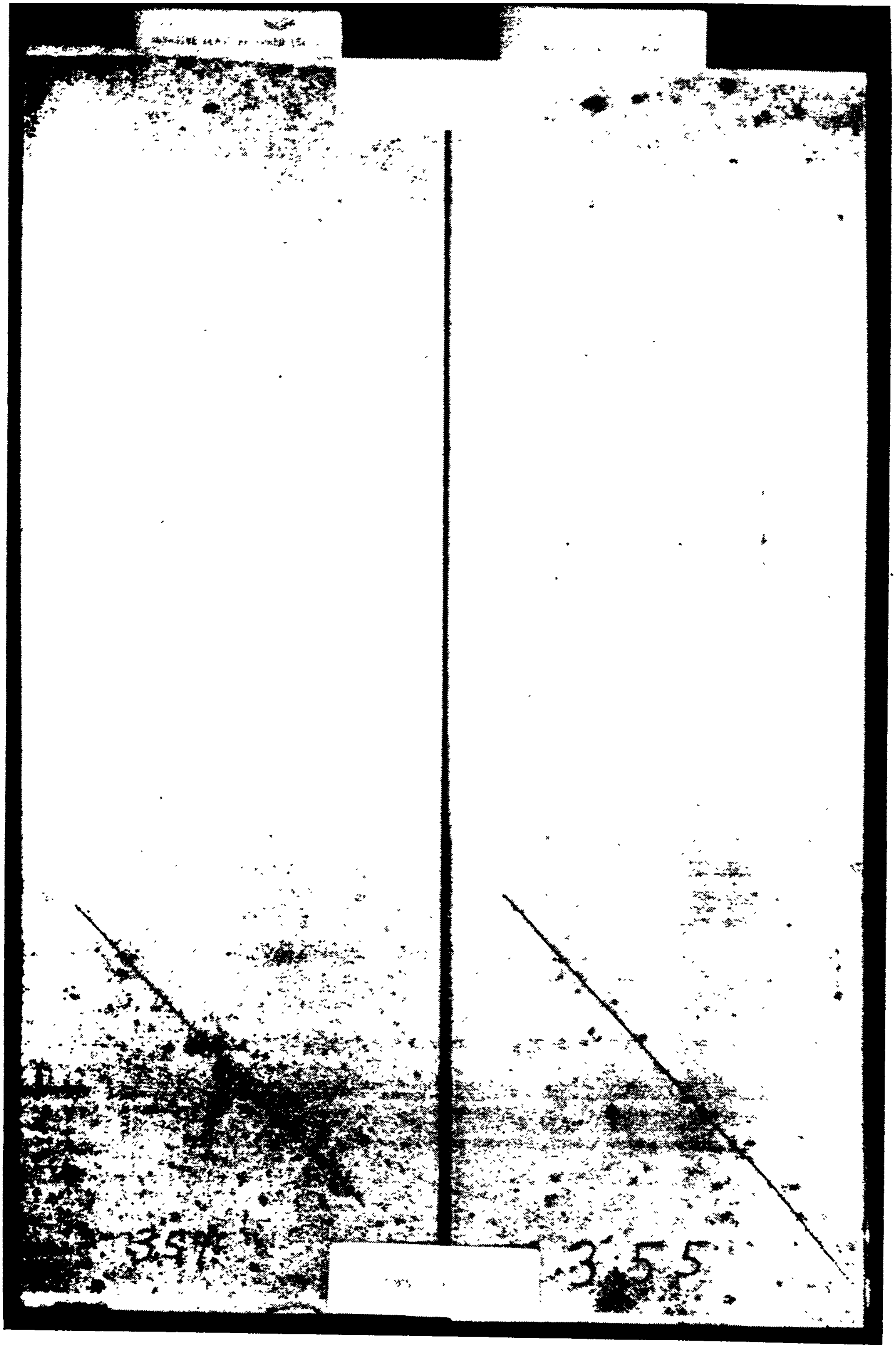


Figure 2.34: Exterior Performance Results of Polyamine
Epoxy Primer After Seven Months Exposure

Figure 2.35: Exterior Performance Results of Vinyl Wash Primer (Mil-P-15328) After Three Months of Exposure

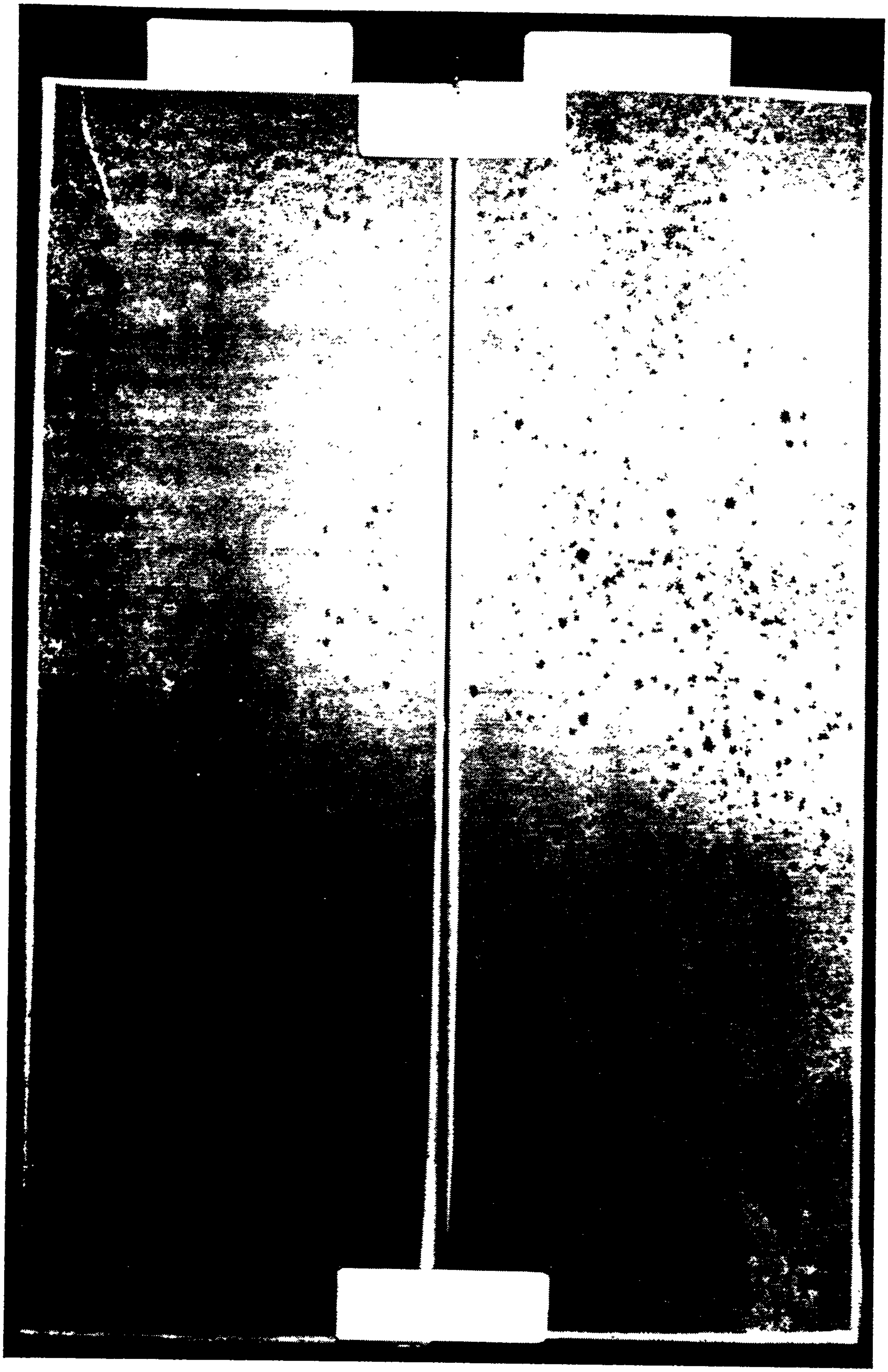


Figure 2.36: Exterior Performance Results of One Component Epoxy Primer After Five Months of Exposure

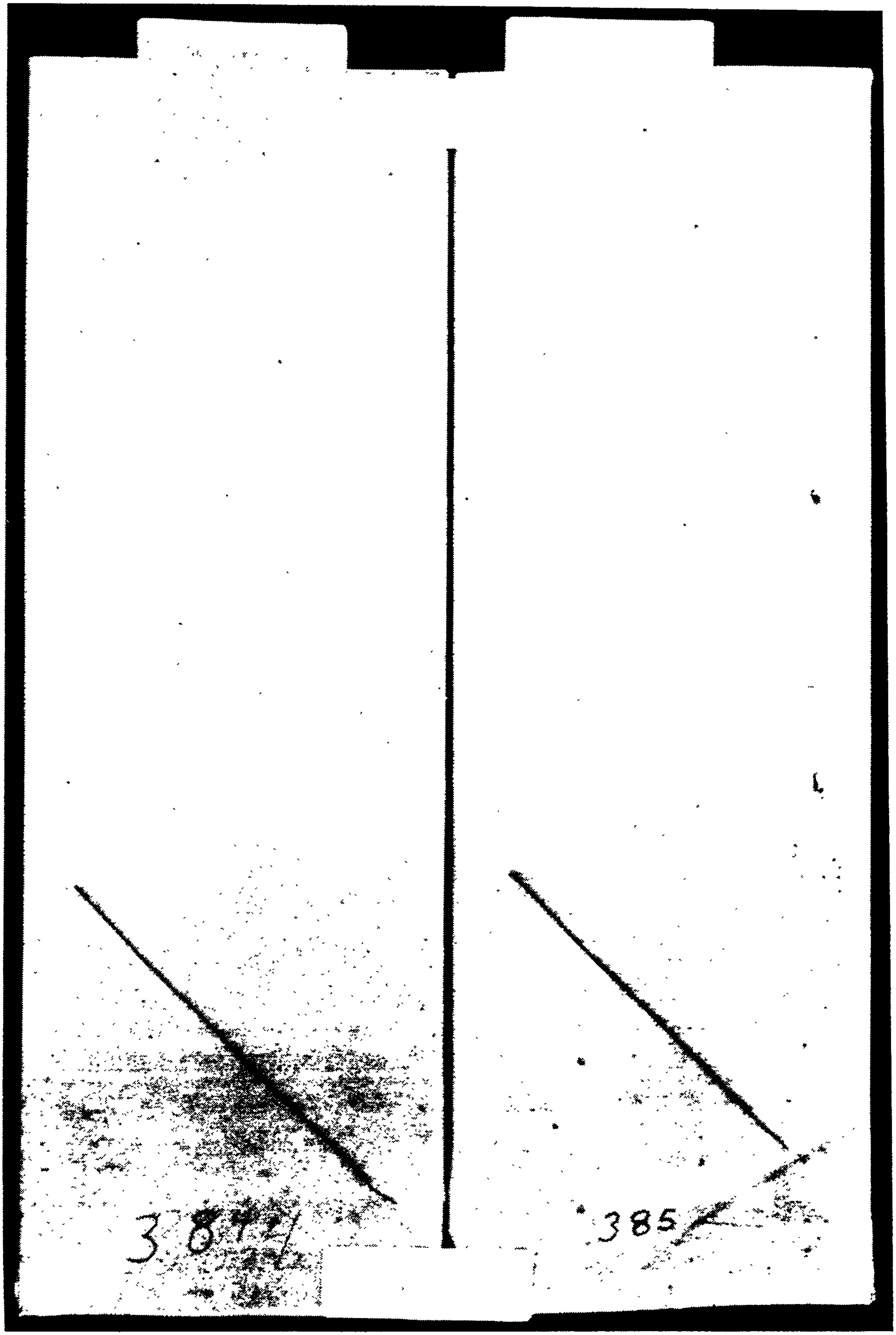


Figure 2.37: Exterior Performance Results of Water Emulsion
Primer After Seven Months Exposure

As stated in paragraph 2.5.2 above, no difference in performance existed between alkyl inorganic zinc primers (solvent. based) applied over abrasive blasted and citric acid cleaned panels.

Ten different' one-component inorganic zinc primers were evaluated. The averaged results are as follows:

	ABRASIVE BLAST	CITRIC ACID
Mean	8.5	9.1
Median	9	9
Mode	9	9

There was no difference in the performance of post cure inorganic zincs and only minor differences in the water based inorganic zincs. The abrasive blasted primers again showed a slightly inferior performance.

The remainder of the other types of zinc rich primers also demonstrated almost identical results.

Table IVA contains statistical results for some of the generic types of primers.

As with the salt fog test, no attempt should be made to compare performance between primers of the same generic type and different suppliers or different generic types without taking into account the actual film thickness of the applied materials.

Figure 2.38 is a photograph showing the results of an improper final rinse. Apparently, some of the passivator solution or original acid solution diffused from the back of the panel onto the front edge. This demonstrates the importance of proper final rinse.

2.5.3.2 Touch-Up Surface Preparation Test Results

Twenty different primers representing twelve generic types were selected at random for the touch-up surface preparation test.

The test panels were 6" X 18", A-36 steel panels which were first abrasive blasted to Steel Structure Painting Council surface preparation "Near White Blast" (SP1O) and then primed. These panels were not descaled and allowed to rust prior to initial priming.

Each primer selected was applied to the top and bottom

TABLE IVA - Statistical Results of Primer Performance

GENERIC TYPE OF PRIMER	ABRASIVE BLAST CLEANED			CITRIC ACID CLEANED		
	MEAN	MEDIAN	MODE	MEAN	MEDIAN	MODE
POLYAMIDE EPOXY	8.3	8	10	9.1	9	10
POLYAMINE EPOXY	8.9	10	10	9	10	10
ALKYD	8.6	8.5	--	9	9	9
VINYL	6.8	7	--	7.8	8	8

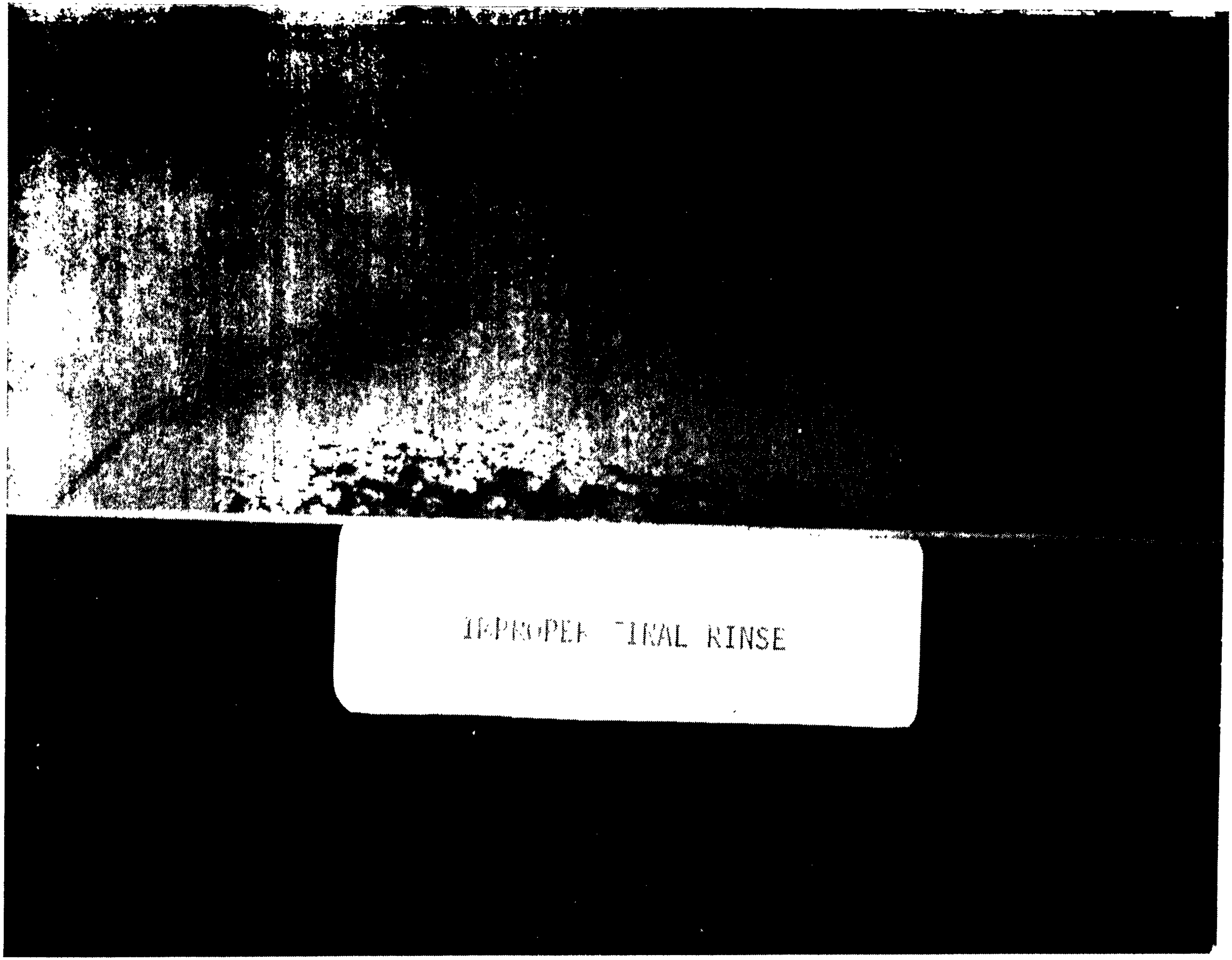


Figure 2.38: Example of Improper Final Rinse

third of two each steel panels. The center third was left bare. Following cure of each coating, a 3/4″ weld was made through a portion of the coating and into the unpainted area. See Figures 2.39 and 2.40 for examples of the panels prior to exposure.

These panels were placed on an exterior test rack at 45° South for ten weeks and allowed to rust. After the exposure period, the panels were removed from the rack and one panel from each set was touch-up cleaned using a citric acid spray technique, and one panel from each set was power tool cleaned in accordance with the procedure defined for erection joints in reference 6, “Catalog of Existing Small Tools for Surface Preparation and Support Equipment for Blasters and Painters”. (See Annex B)

During the citric acid operation it was noted that the citric acid reacted with the alkyl inorganic zinc types of primers (solvent based) and removed the majority of the zinc leaving the panel essentially bare. The water based self cure was removed to a lesser degree and the post cure inorganic zinc was not distrubed.

It must also be pointed out that the citric process did not remove residual weld slag or heat damaged partially adhering initial primer. No attempt was made to supplement the citric acid cleaning with mechanical cleaning prior to touch-up priming.

The touched-up panels were reprimed and then replaced on the exterior test fence at 45° South for seven months. Table V contains a tabulation of the test results.

The overall performance of the-citric acid touch-up cleaned surfaces was inferior to the power tool touch-up cleaned surfaces. The primary reason for this divergence of performance from the previously discussed tests can be explained by review of Figures 2.41, 2.42 and 2.43. Figure 2.41 is a closeup of a test weld prior to initial exposure or cleaning. Note the weld damaged paint, residual weld slag and weld splatter. Now look at Figure 2.42, note the failure points. In each case, the primer failures are associated with weld slag, splatter or weld damaged primer.

TABLE V: Touch-up Surface Preparation Performance of Various Primers Applied to Either Power Tool Cleaned or Citric Acid Cleaned Prepared Panels

GENERIC TYPE	SUPPLIER	PRODUCT NUMBER	TOUCH-UP SURFACE PREPARATION	FILM THICKNESS (MILS)	SEVEN MONTH PERFORMANCE RATING
Post Cure Inorganic Zinc	Ameron	D-3	Power Tool	5.6	10
			Citric Acid	5.3	10
Water Based, Self Cure Inorganic Zinc	Ameron	D4	Power Tool	2.5	9
			Citric Acid	2.1	9
Alkyl Inorganic Zinc	Carboline	CZ11	Power Tool	4.8	10
			Citric Acid	4.3	10
Alkyl Inorganic Zinc	Mobil	13F12	Power Tool	3.3	10
			Citric Acid	2.7	10
Alkyl Inorganic Zinc	Sigma	711G	Power Tool	4.0	10
			Citric Acid	3.4	10
Alkyl Inorganic Zinc	Mobile	28DH50	Power Tool	2.3	10
			Citric Acid	1.8	10
One Component Inorganic Zinc	Devoe	306	Power Tool	5.6	9
			Citric Acid	4.6	9
One Component Inorganic Zinc	Mobil	13G10	Power Tool	2.2	10
			Citric Acid	1.6	10
Modified Inorganic Zinc	Porter	352	Power Tool	3.0	10
			Citric Acid	2.5	10
One Component Epoxy Zinc Rich	Napko	1355	Power Tool	5.6	9
			Citric Acid	4.5	9
Polyamide Epoxy	Carboline	193HB	Power Tool	5.6	10
			Citric Acid	4.3	9
Polyamide Epoxy	Devoe	208	Power Tool	2.4	7
			Citric Acid	2.0	8
Polyamide Epoxy	Napko	5616	Power Tool	2.4	10
			Citric Acid	1.8	10
Polyamine Epoxy	Porter	7650	Power Tool	2.1	7
			Citric Acid	1.5	8
Polyamine Epoxy	Sigma	7433	Power Tool	7.4	10
			Citric Acid	7.0	10
Alkyd	Imperial	62	Power Tool	4.7	10
			Citric Acid	5.4	9
Alkyd	Mobile	28DR105	Power Tool	1.6	7
			Citric Acid	2.0	6
Chlorinated Rubber	Imperial	880	Power Tool	6.0	10
			Citric Acid	6.3	10
One Component Epoxy	International	NEA200	Power Tool	3.4	10
			Citric Acid	3.3	9
Ketamine Epoxy	International	TTA424	Power Tool	5.9	9
			Citric Acid	5.8	9
			Power Tool		
			Citric Acid		
			Power Tool		
			Citric Acid		
			Power Tool		
			Citric Acid		
			Power Tool		
			Citric Acid		
			Power Tool		
			Citric Acid		

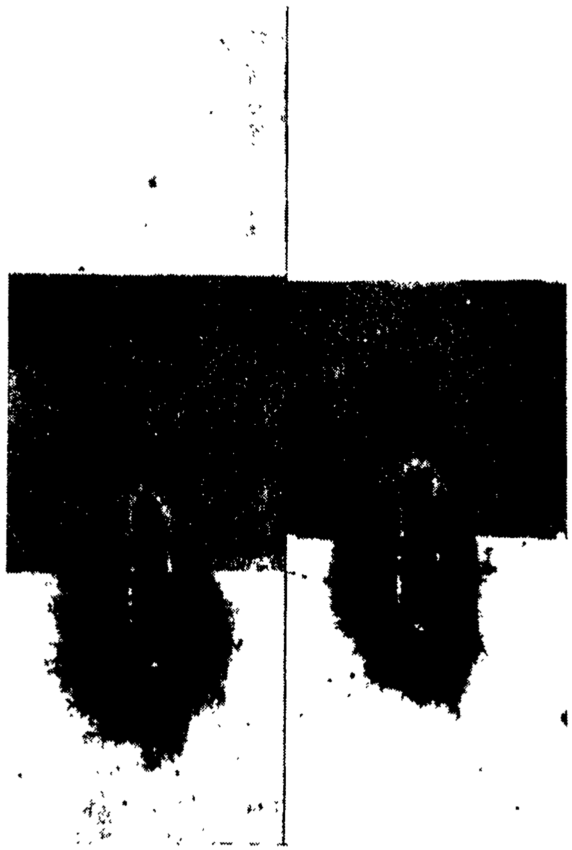


Figure 2.39: Example of Epoxy Touch Up Panel Prior to Exposure

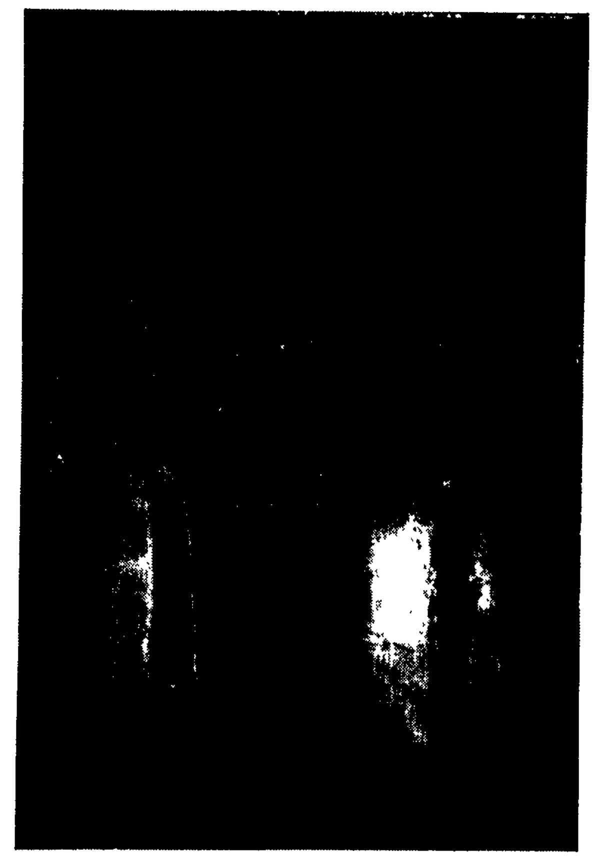


Figure 2.40: Example of Inorganic Zinc Touch Up Panel Prior to Exposure

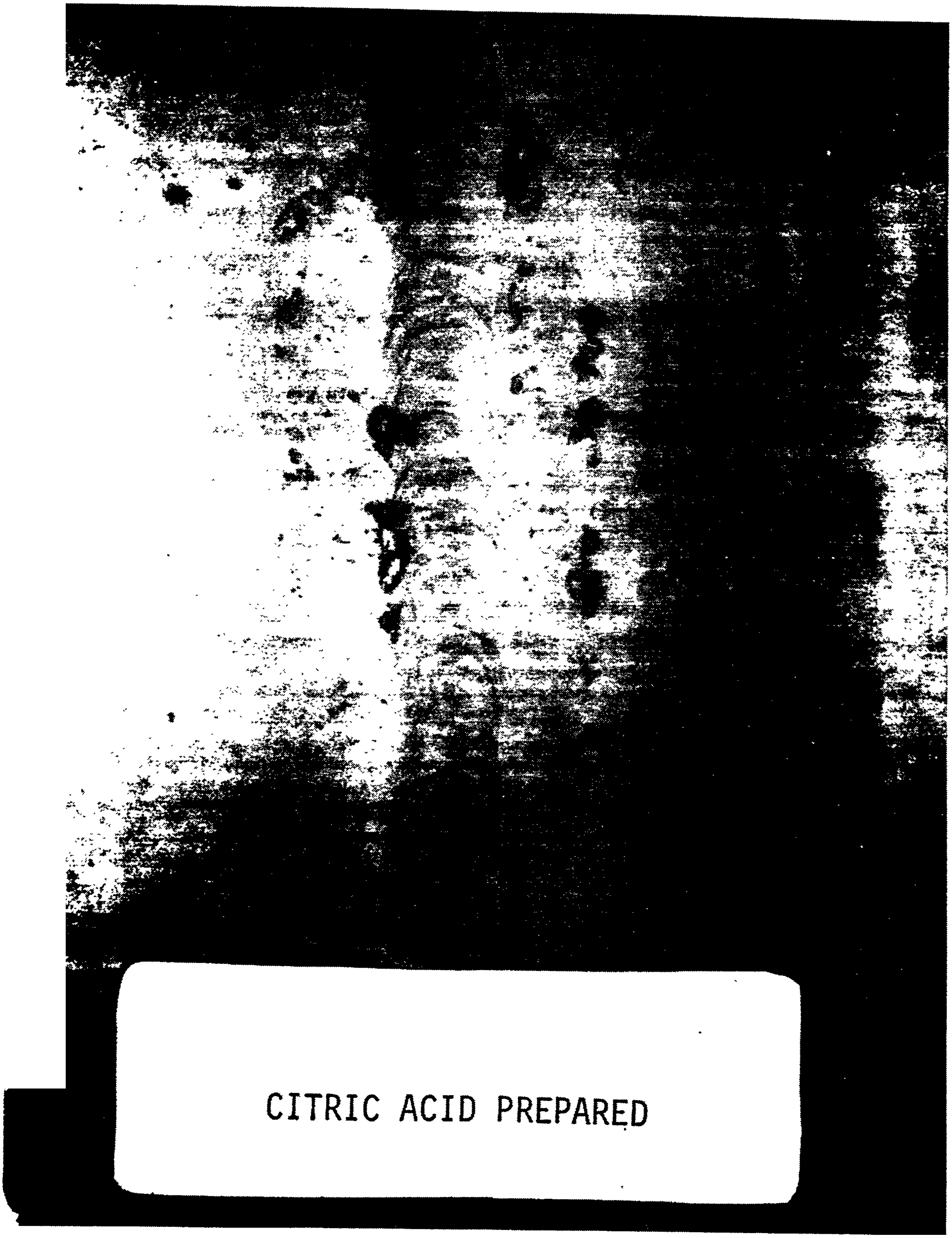


Figure 2.42: Example of Citric Acid Cleaned and Passivated Touch-Up Panel After Initial Exposure, Touch-Up and Reexposure

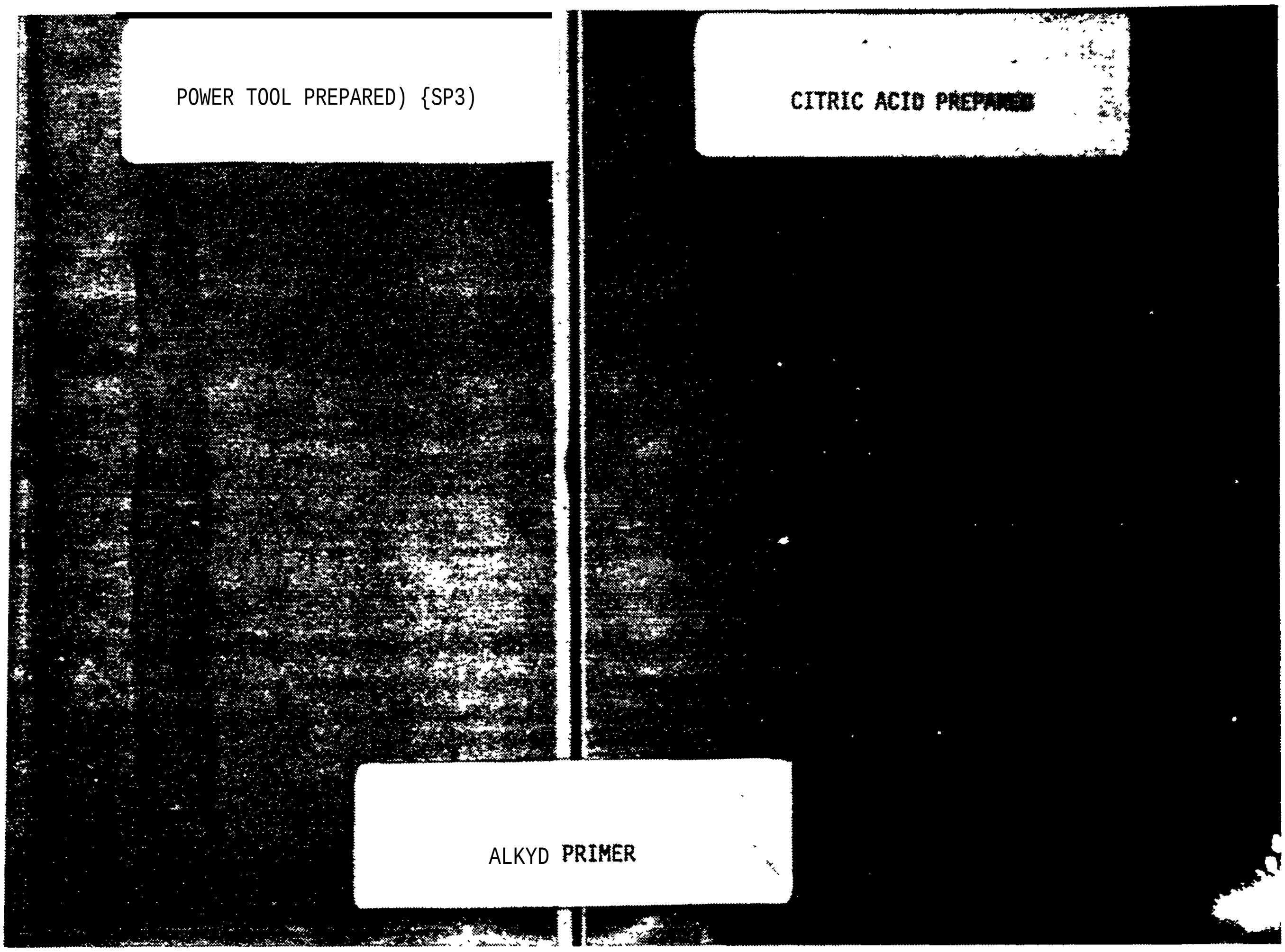


Figure 2.43: Direct Comparison of Power Tool Cleaned and Citric Acid Cleaned Touch-Up Panels After Seven Months Re-exposure

Figure 2.43 also shows a direct comparison of the performance of power tool cleaning and citric acid cleaning. Again, the primer failure is due to weld damaged paint. In concLusion, citric acid cleaning for touch-up of damaged weld areas must be supplemented with a mechanical cleaning method to remove residual slag, weld splatter, and damaged paint.

2.6 Tank Coatings Test

The fourth test environment was selected to be representative of ships clean ballast and fresh water storage tanks.

Ten generic tank coatings from s-ix suppliers were randomly selected for test. Each coating system was applied to two pre-rusted A-36 steel panels (6″ X 6“) which had been subsequently cleaned via citric acid or abrasive blasting (SP10). One each citric acid prepared and one each abrasive blast prepared panel, both coated with the same coating system, were-tested in one of two test tanks.

The first test tank was filled with synthetic seawater at a controlled temperature of 100″F. Each panel was scribed through the coating system to the substrate prior to immersion. After the panels were immersed in the synthetic sea water, the tank was subjected to an approximate hydrostatic head of 200 feet (~ 80 psi) for thirty days. A running air pressure was maintained to keep the seawater aerated, i.e. compressed air was-bubbled through the tank for the duration.

The second tank was charged with deionized water (2.5 million ohms). The test panels were subjected to the same hydrostatic head as noted in the first tank to include aeration of liquid. The initial duration of the test was thirty days at 100°F controlled~temperature. No difference in performance was noted after thirty days; therefore, the deionized water was replaced with fresh deionized water, and the panels reexposed for an additional thirty days. During the second exposure interval, the controlled temperature was increased to 130°F.

2.6.1 Synthetic Sea Water Test Results

The results of the synthetic seawater tests are summarized in Table VI. Blister rating was evaluated in accordance with ASTM Standard D714. Adhesion value was determined utilizing an “Elcometer” button-pull adhesion tester. Figures 2.44 through 2.51 are photographs of the relative performance of each set of generic coating systems. In figure 2.44, the abrasive blast panels are on the top row and the citric acid panels are on the bottom. For

TABLE VI: Hydrostatic, Salt Water, Tank Coating Test Results

GENERIC TYPE	SUPPLIER	PRODUCT NUMBER	SURFACE PREPARATION	TOTAL FILM THICKNESS (MILS)	BLISTER RATING	ADHESION VALUE (PSI)	PHOTOGRAPHIC FIGURE NO.	PANEL NO.
POST CURE INORGANIC ZINC	Ameron	D-3	Abrasive Blasted (SP10)	2.8	NONE	Not Tested	2.44	499
			Citric Acid	2.8	NONE	Not Tested	2.44	447
WATER BASED INORGANIC ZINC	Ameron	D-4	Abrasive Blasted (SP10)	3.8	NONE	Not Tested	2.44	451
			Citric Acid	3.0	NONE	Not Tested	2.44	453
ALKYL INORGANIC ZINC (SOLVENT BASED)	Mobil	13F12	Abrasive Blasted (SP10)	4.5	NONE	Not Tested	2.44	463
			Citric Acid	4.8	NONE	Not Tested	2.44	465
VINYL	Ameron	33	Abrasive Blasted (SP10)	6.3	#6 Med. Den.	200	2.45	459
			Citric Acid	6.0	#6 Med. Den.	300	2.45	461
POLYAMIDE EPOXY	Ameron	81/82	Abrasive Blasted (SP10)	9.3	2 each #2	350	2.46	455
			Citric Acid	8.3	1 each #2	400	2.46	457
POLYAMIDE EPOXY	Devoe	207	Abrasive Blasted (SP10)	9.2	27 each #4 plus 8 Few	250	2.46	483
			Citric Acid	9.0	3 each #4 plus 8 Few	800	2.46	485
COAL TAR EPOXY	Carboline	CM14	Abrasive Blasted (SP10)	13.5	1 each #2 plus 2 each #4	250	2.47	471
			Citric Acid	13.5	NONE	400	2.47	473
COAL TAR EPOXY	International	C200	Abrasive Blast (SP10)	12.5	#2 Few around Scribe	500	2.47	495
			Citric Acid	11.5	1 each #2	500	2.47	497
POLYAMINE EPOXY	Carboline	187HFP	Abrasive Blast (SP10)	12.0	#4 Med.	400	2.48	467
			Citric Acid	11.0	1 each #4	1000	2.48	469

TABLE VI: (cont'd.)

TABLE VI: Hydrostatic, Salt Water, Tank Coating Test Results

GENERIC TYPE	SUPPLIER	PRODUCT NUMBER	SURFACE PREPARATION	TOTAL FILM THICKNESS (MILS)	BLISTER RATING	ADHESION VALUE (PSI)	PHOTOGRAPHIC FIGURE NO.	PANEL NO.
PHENOLIC EPOXY	Byco	2222	Abrasive Blast (SP10)	8.3	#2 Few around Scribe	400	2.49	479
			Citric Acid	8.0	#6 Med. Den. around Scribe	800	2.49	481
KETAMINE EPOXY	Devoe	244HS	Abrasive Blast (SP10)	9.0	#2 Few around Scribe	350	2.50	487
			Citric Acid	8.0	NONE	850	2.50	489
KETAMINE EPOXY	International	TTA424/ TTA421	Abrasive Blast (SP10)	9.0	#4 Few around Scribe	600	2.50	491
			Citric Acid	8.0	1 each #4	700	2.50	493
AMINE ADDUCT EPOXY	Mobil	264W12B/ 264T24/ 264F25B	Abrasive Blast (SP10)	6.0	#4 Few around Scribe	550	2.51	499
			Citric Acid	6.0	#4 Few around Scribe	600	2.51	501

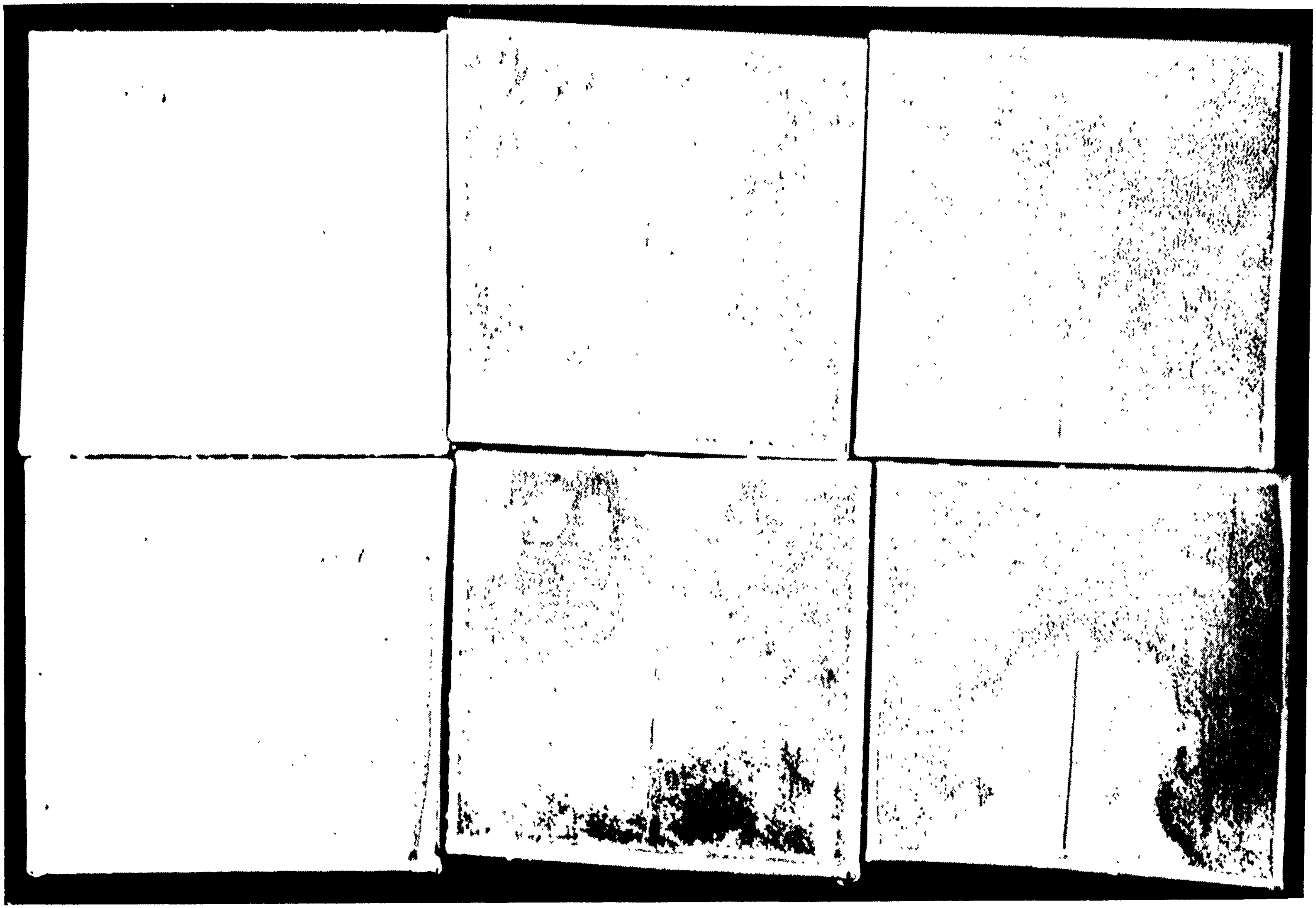


Figure 2.44: Photographs of Inorganic Zinc Tank Coatings After

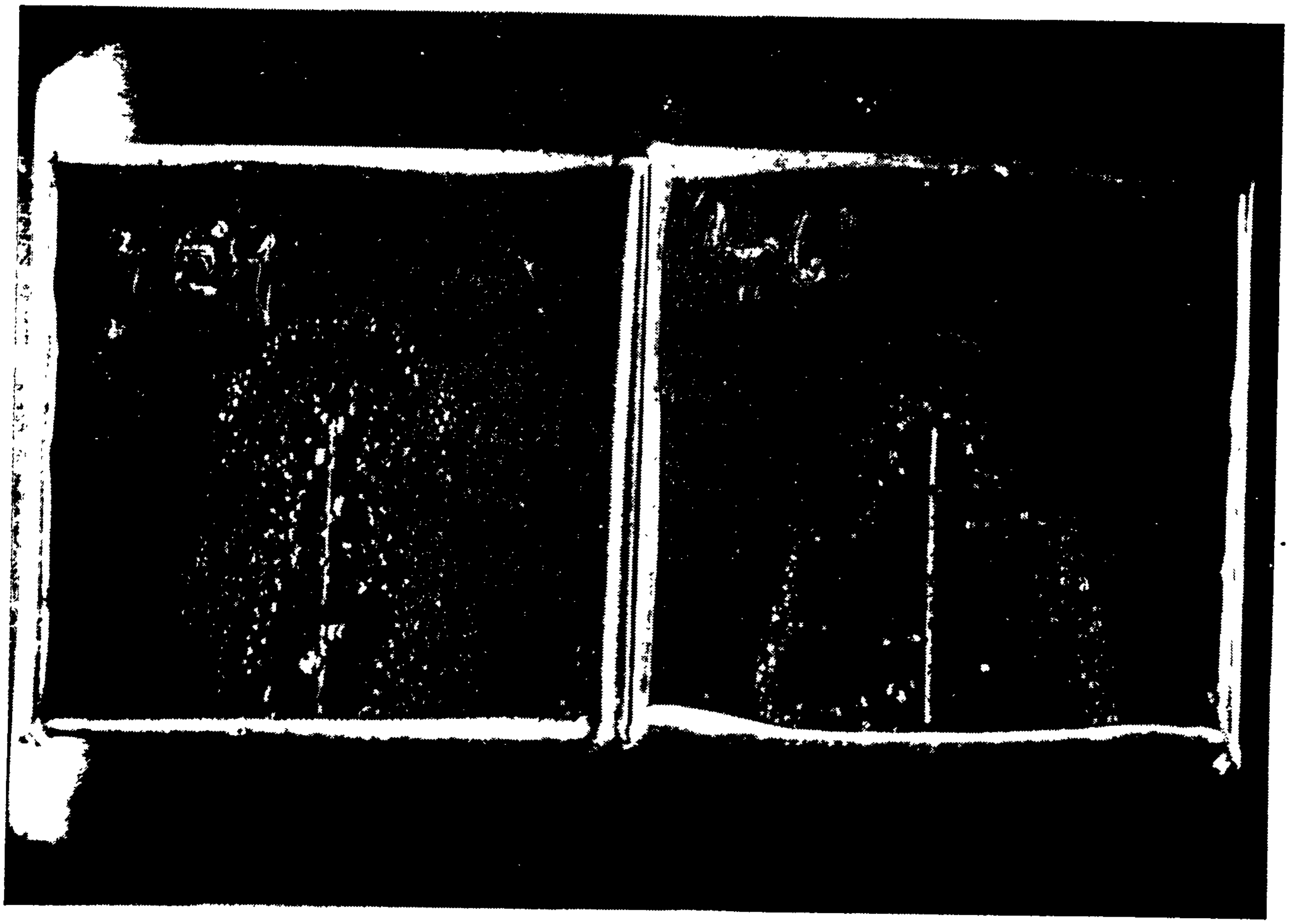


Figure 2.45: Photograph of Vinyl Tank Coatings
After Thirty Days Exposure in Hydrostatic Test Tank Filled
With Synthetic Sea Water

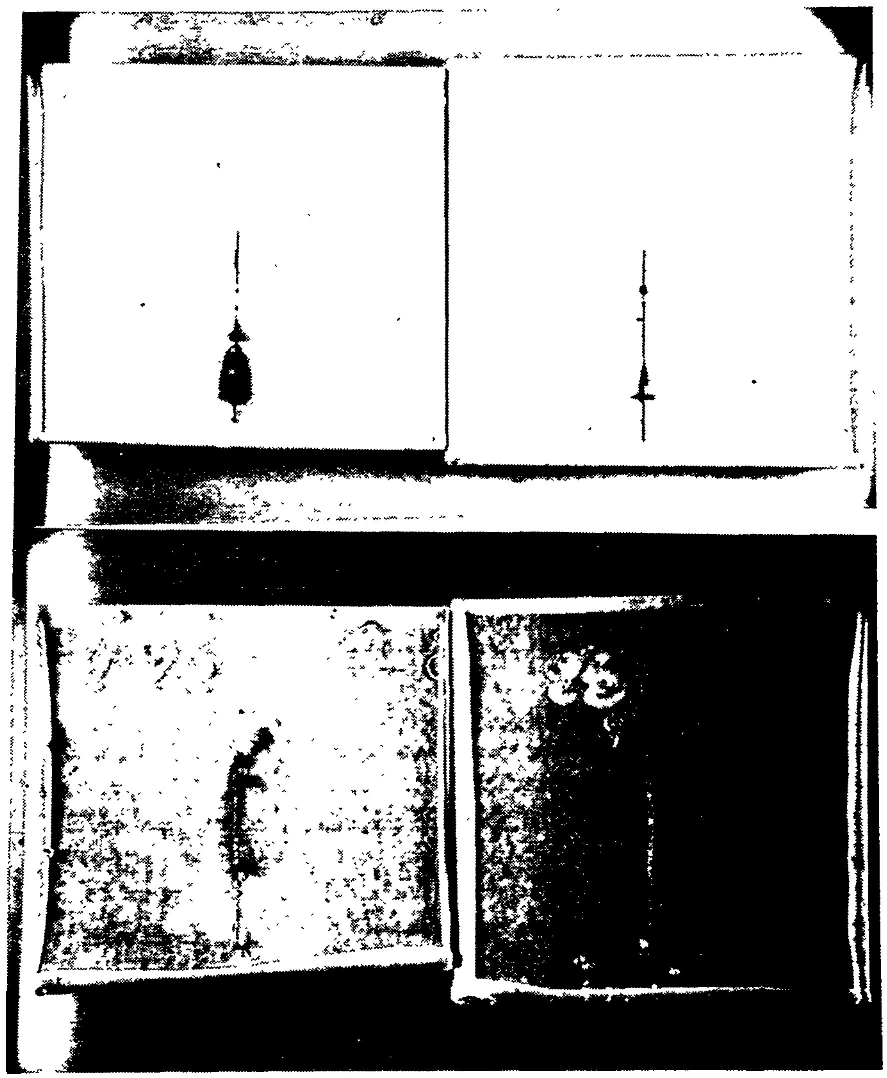


Figure 2.46: Photographs of Polyamide Epoxy Tank Coatings After Thirty Days Exposure in Hydrostatic Test Tank Filled with Synthetic Sea Water

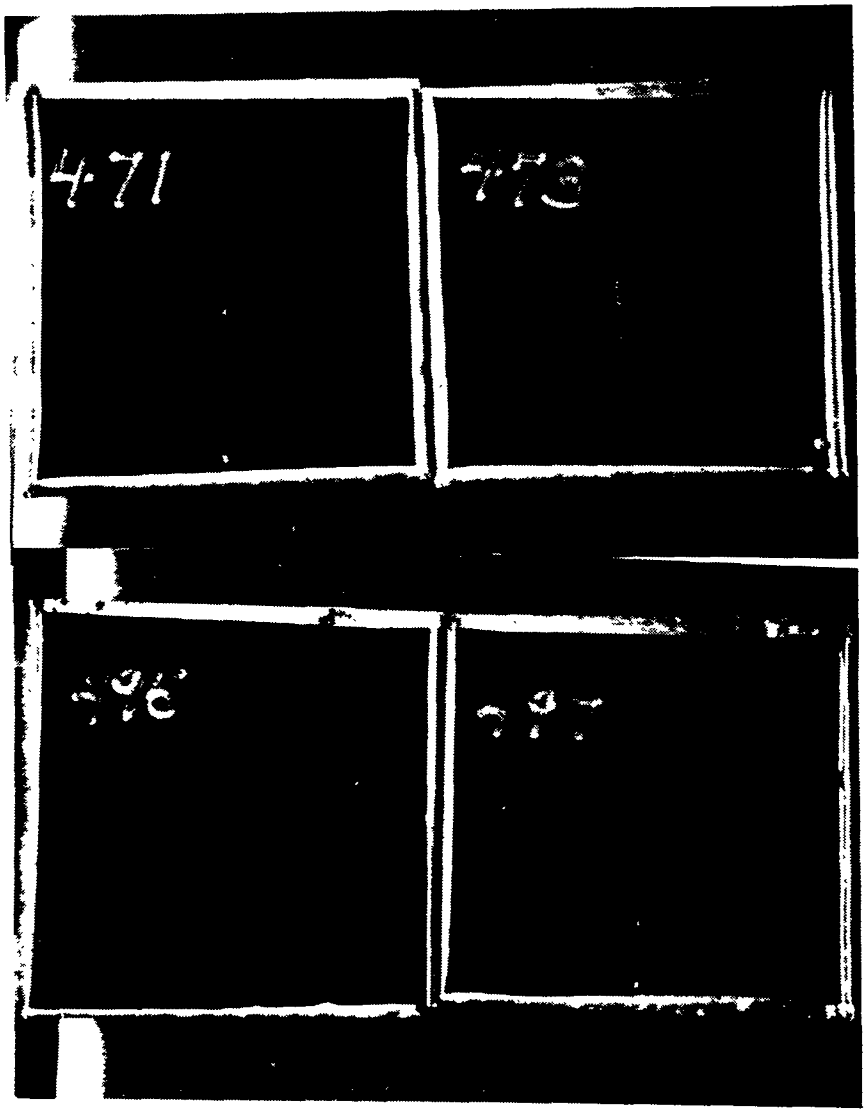


Figure 2.47: Photographs of Coal Tar Epoxy Tank Coatings After Thirty Days Exposure in Hydrostatic Test Tank Filled With Synthetic Sea Water

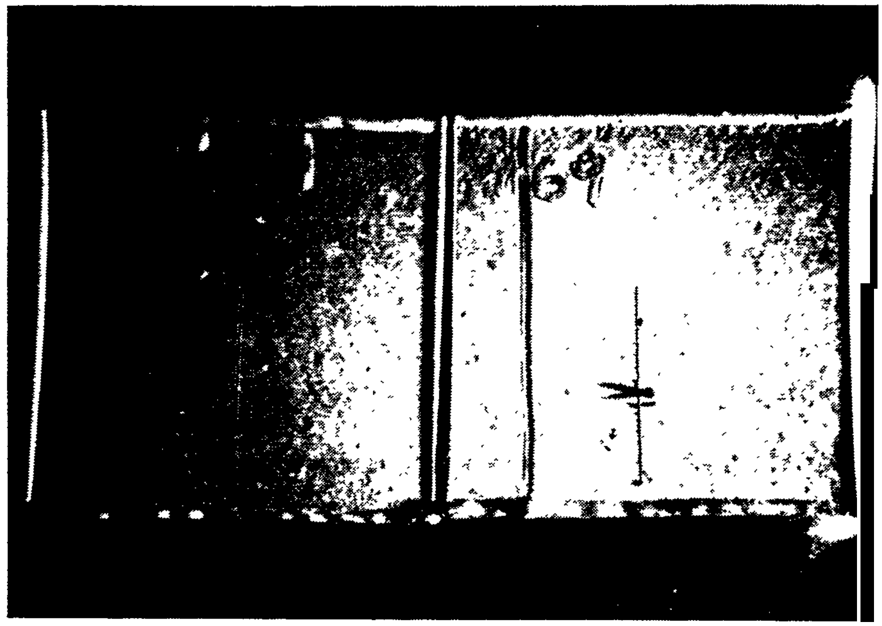


Figure 2.48: Photograph of Polyamine Epoxy Tank Coating After Thirty Days Exposure in Hydrostatic Test Tank Filled With Synthetic Sea Water

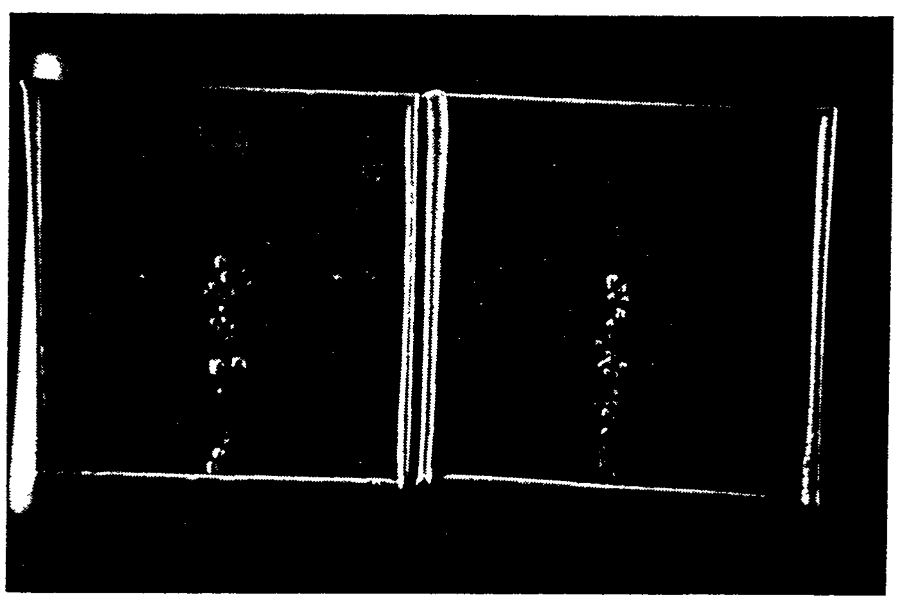


Figure 2.49: Photograph of Phenolic Epoxy Tank Coating After Thirty Days Exposure in Hydrostatic Test Tank Filled With Synthetic Sea Water

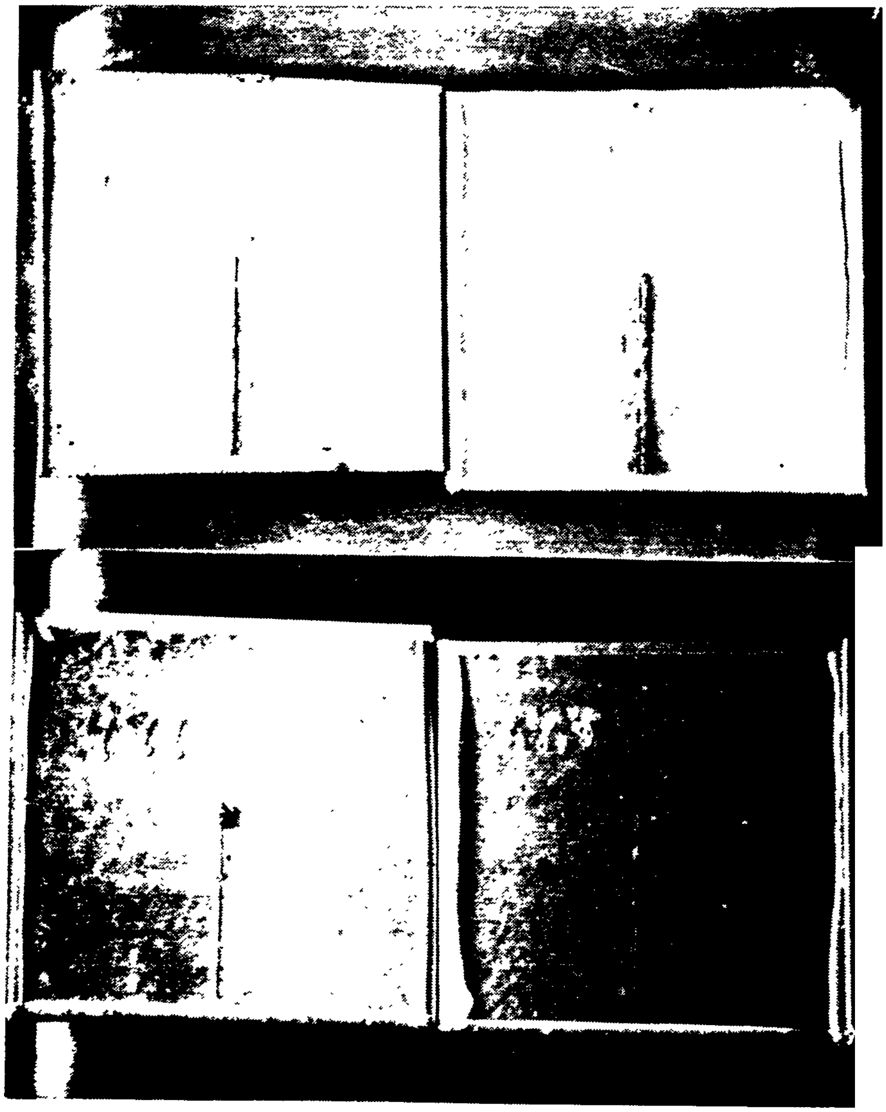


Figure 2.50: Photographs of Ketamine Epoxy Tank Coatings After Thirty Days Exposure in Hydrostatic Test Tank Filled With Synthetic Sea Water

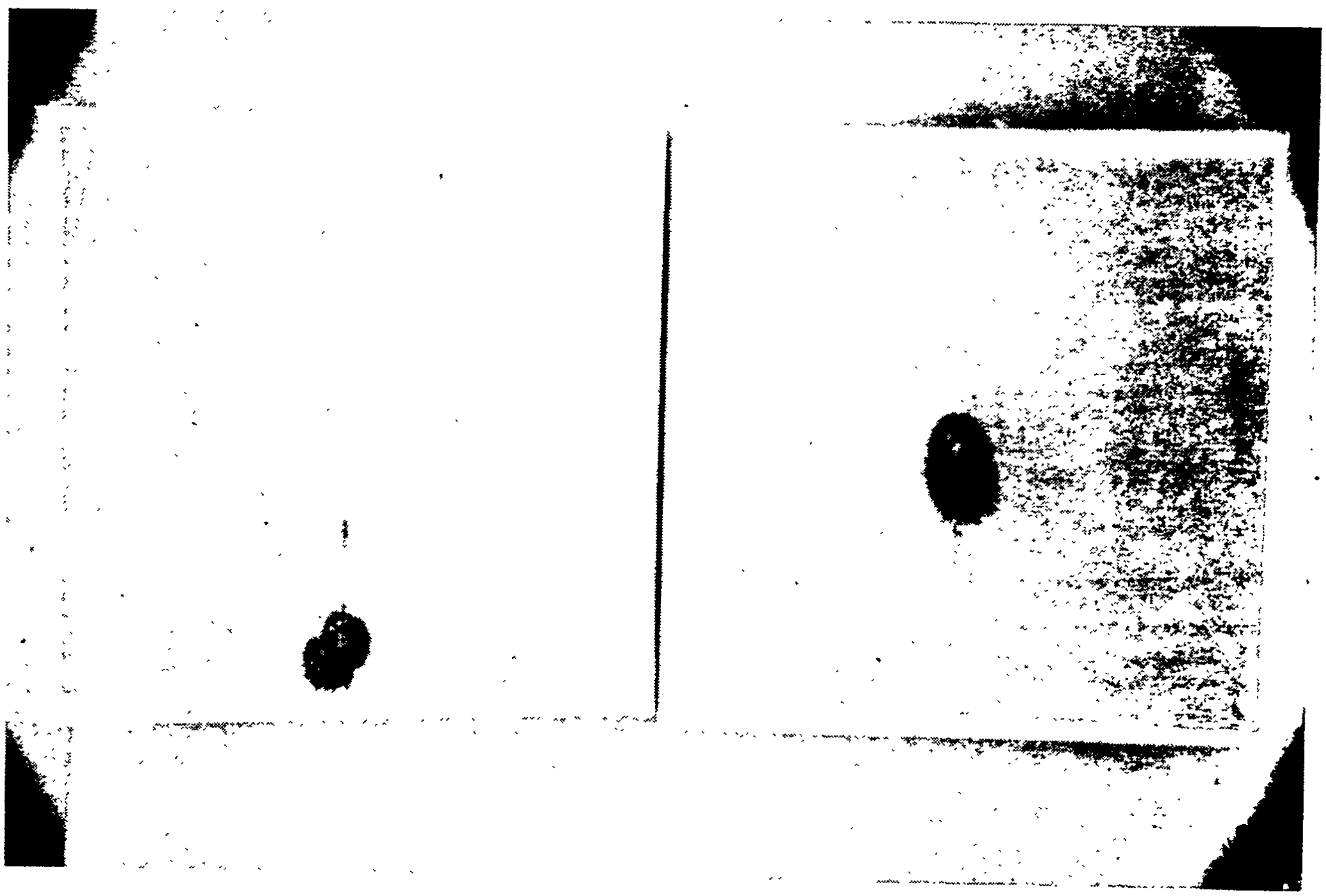


Figure 2.51: Photograph of Amine Adduct Epoxy Tank Coating After Thirty Days Exposure in Hydrostatic Test Tank Filled With Synthetic Sea Water

figures 2.45 through 2.51, the abrasive blasted are on the left and citric acid on the right.

In summary, the citric acid prepared panels outperformed the abrasive blast prepared panels. Special mention must be made of the fact that the adhesion values of the citric acid cleaned panels were equal to or greater than the abrasive blast prepared panels. Note the Devoe 207 tested system. The value of the citric acid cleaned adhesion was over three times greater. The adhesion test was carried out by gluing the test “dolly” immediately over the scribe mark; therefore, the adhesive values are probably a measure of or influenced by the underfilm corrosion. This phenomenon deserves further investigation during some future tank coating test project.

2.6.2 Deionized Water Test Results

The results of the deionized water, hydrostatic tank coatings test are summarized in Table VII. Blistering was evaluated in accordance with ASTM D714. Both sides of the panel were graded. In the case of the deionized water test, the superior performance of the citric acid cleaned panels was not as well defined as with the other tests. In fact, the overall average performance of the citric acid cleaned surfaces was slightly inferior to the abrasive blast cleaned surfaces. However, a case by case evaluation demonstrates that with some generic coatings, the citric acid cleaned panels outperformed the abrasive blast cleaned panels. Carboline Vinyl TD72, Ameron Polyamide Epoxy 81/82, and Devoe Polyamide Epoxy 207 are examples of superior citric acid performance. The International C-200 and Carboline 187HFP Polyamine Epoxy are examples of inferior performance. It must be noted that the performance rating of the citric acid cleaned C-200 panel is only slightly below the abrasive blast panel. Close examination of the 187HFP panel reveals a geometric pattern of blisters concentrated along the edges of one side of the panel (See. Figure 2.52). The other side of the panel is devoid of blisters. This geometric pattern could be the result of inadequate final rinse as noted with the performance of an exteriorly exposed panel (See Figure 2.38). Figure 2.53, a phenolic epoxy, shows complete failure of the coating over both substrates. The citric acid panel has six such blisters which are larger than the remainder of the blisters on both panels. These larger blisters could indicate reduced adhesion.

TABLE VII: Hydrostatic,
Deionized Water, Tank Coatings Test Results

GENERIC TYPE	SUPPLIER	PRODUCT NUMBER	SURFACE PREPARATION	FILM THICKNESS (MILS)	BLISTER RATING	PANEL NUMBER
POST CURE INORGANIC ZINC	Ameron	D-3	Abrasive Blast	2.8	NONE	448
			Citric Acid	2.0	NONE	446
WATER BASED INORGANIC ZINC	Ameron	D-4	Abrasive Blast	4.0	NONE	450
			Citric Acid	3.0	NONE	452
ALKYL INORGANIC ZINC (SOLVENT BASED)	Mobil	13F12	Abrasive Blast	4.5	NONE	462
			Citric Acid	5.0	NONE	464
VINYL	Ameron	33	Abrasive Blast	6.0	NONE	458
			Citric Acid	6.0	NONE	460
VINYL	Carboline	TD72	Abrasive Blast	6.0	#6 Med.	474
			Citric Acid	6.5	#6 Med. one side only	476
POLYAMIDE EPOXY	Ameron	81/82	Abrasive Blast	8.25	#4 Med.	454
			Citric Acid	8.25	#4 Few one side only	456
POLYAMIDE EPOXY	Devoe	207	Abrasive Blast	9.0	#6 Med. Den.	482
			Citric Acid	9.0	#8 Med.	484
COAL TAR EPOXY	Carboline	CM14	Abrasive Blast	13.0	NONE	470
			Citric Acid	13.5	NONE	472
COAL TAR EPOXY	International	C200	Abrasive Blast	12.0	NONE	494
			Citric Acid	12.0	#6 Med. Top edge only one side	496

TABLE VII: (cont'd.)

TABLE VII: Hydrostatic,
Deionized Water, Tank Coatings Test Results

GENERIC TYPE	SUPPLIER	PRODUCT NUMBER	SURFACE PREPARATION	FILM THICKNESS (MILS)	BLISTER RATING	PANEL NUMBER
POLYAMINE EPOXY	Carboline	187HFP	Abrasive Blast	12.0	NONE	466
			Citric Acid	11.0	#4 Med one side only (Fig.2.52)	468
PHENOLIC EPOXY	Byco	2222	Abrasive Blast	7.75	#4 Den.	478
			Citric Acid	8.25	#4 Den.	480
KETAMINE EPOXY	Devoe	244HS	Abrasive Blast	9.0	NONE.	486
			Citric Acid	9.0	#8 Few one side only	488
KETAMINE EPOXY	International	TTA424/ TTA421	Abrasive Blast	10.0	#8 Few	490
			Citric Acid	9.5	#8 Few	492
AMINE ADDUCT EPOXY	Mobil	264W12B/ 264T24/ 264F25B	Abrasive Blast	6.0	NONE	498
			Citric Acid	6.0	NONE	500

In sumnary, the citric acid prepared panels performed as well as or superior to the abrasive blast prepared panels in twelve of the fourteen generic systems tested. Of the two systems with inferior performance, one system was slightly inferior and the other markedly inferior on one side of the panel only.

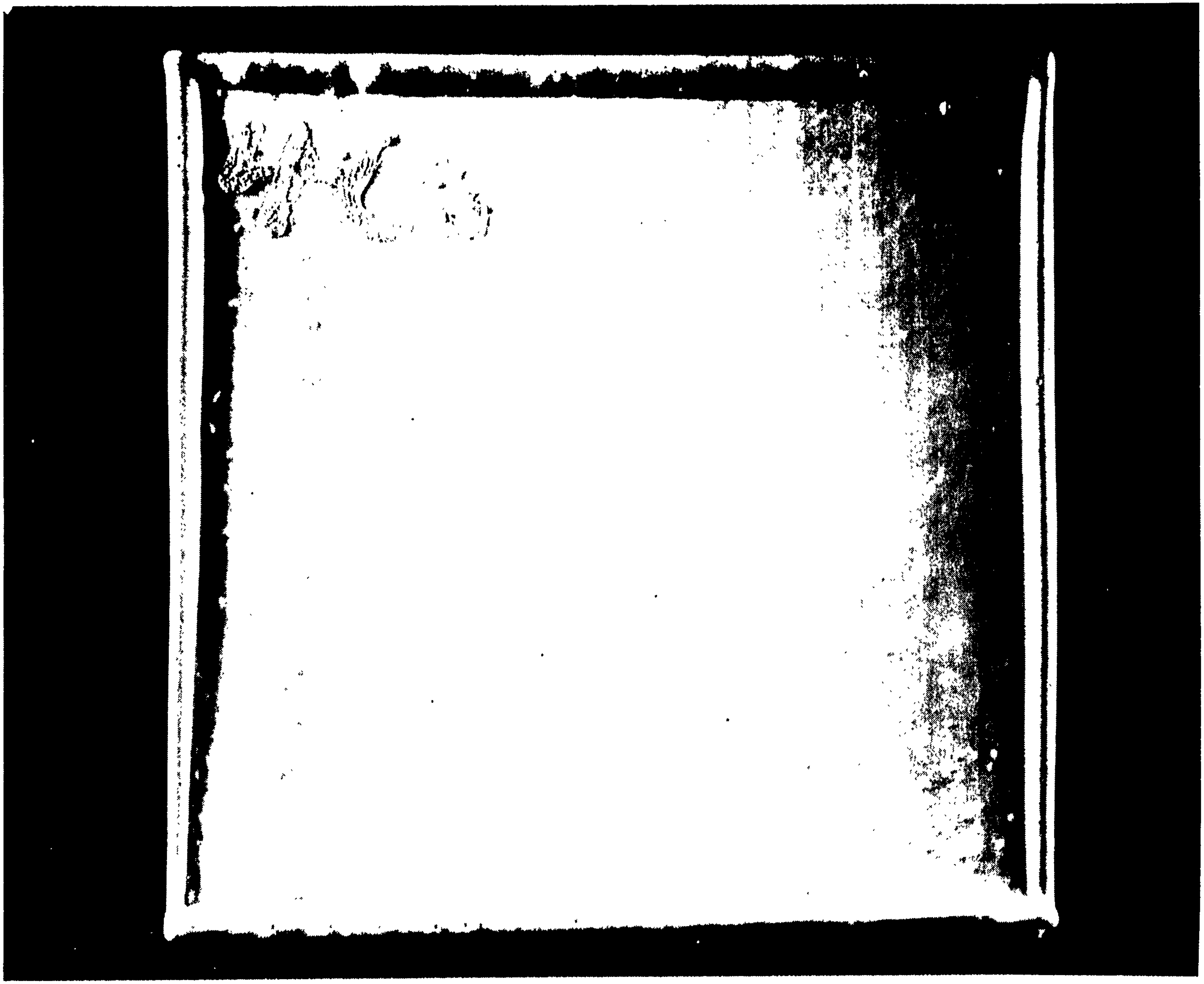


Figure 2.52: Photograph of Geometric Pattern of Blisters
on Panel Exposed in Deionized Water Filled Hydrostatic Test Tank

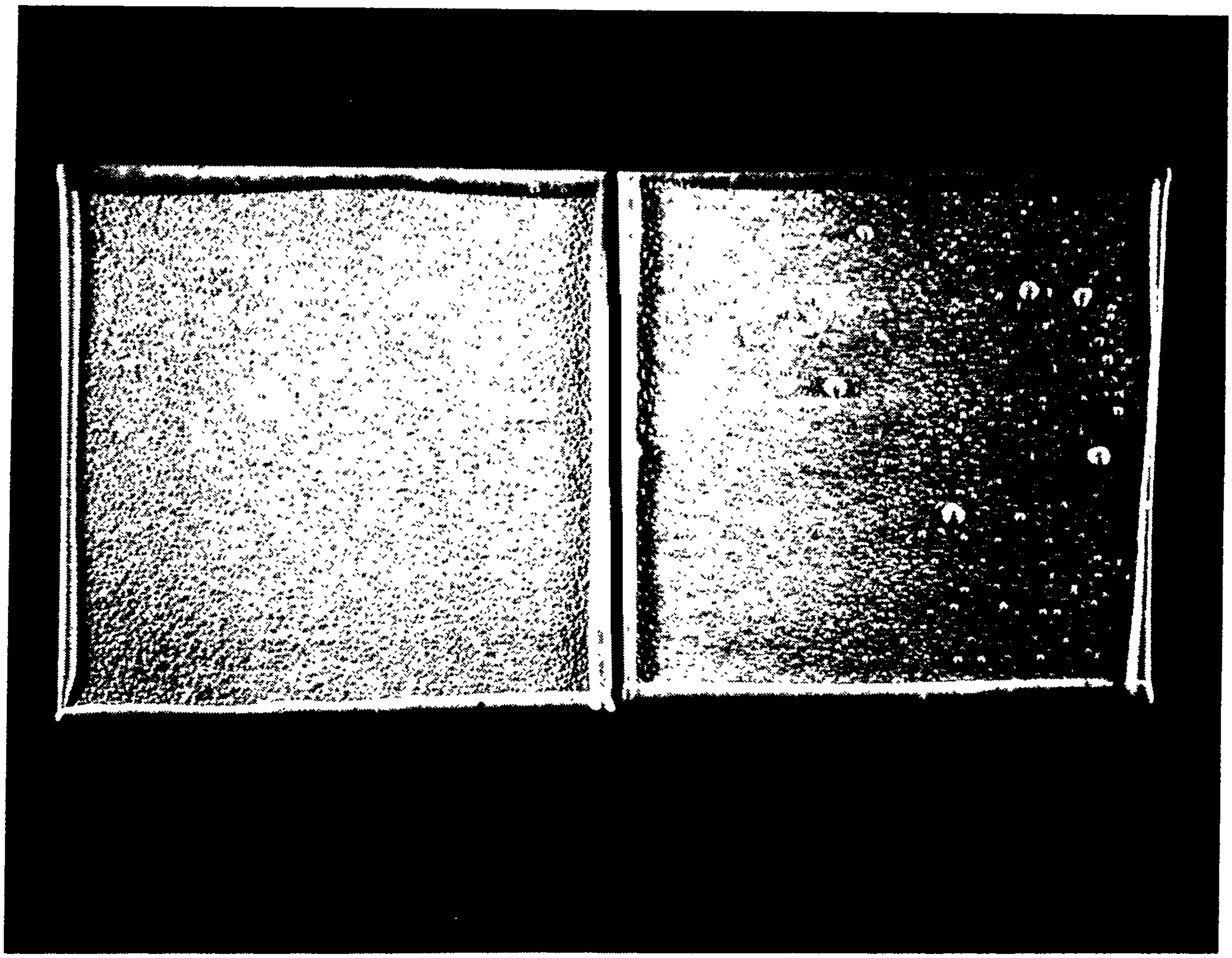


Figure 2.53: Photograph of Phenolic Epoxy Tank Coating
After Sixty Days Exposure in Hydrostatic Test Tank Filled With Deionized Water

SECTION 3
BIBLIOGRAPHY

3. BIBLIOGRAPHY

1. Blume, William J., "Citric Acid Based Chemical Cleaning Processes", Materials Performance, pp 15-19, March 1977.

2. Engle, J. P., "Kinetics Pertaining to Corrosion of Carbon Steel During Chemical Cleaning", Paper No. 2, given at Corrosion 79, National Association of Corrosion Engineers March 12-16, 1979, Atlanta Hilton, Atlanta, Georgia.

3. Hoar, T. P., "Nitrite Inhibition of Corrosion: Some Practical Cases", Corrosion, May, 1958.

4. Keane, John D., "Surface Preparation, New Trends in the Anti-Corrosion Coatings", a paper given at the International Congress, Milan, 22-230

5. Mellors, G. W., Cohen, M., Beck, A. F., "A Study of the Effect of Chloride Ion on Films Formed on Iron in Sodium Nitrite Solutions", Journal of the Electrochemical Society, June, 1958:

6. Peart, John and Unthank, D., "Catalog of Existing Small Tools for Surface Preparation and Support Equipment for Blasters and Painters", The National Shipbuilding Research Program, May, 1977.

7. Roebuck, A. H., "Safe Chemical Cleaning", Paper No. 206 given at Corrosion 78, National Association of Corrosion Engineers, March 6-10, 1978. Albert Thomas Convention Center, Houston, Texas.

8. Spring, S., "Industrial Cleaning", Wilke and Company Limited, Clayton, Victoria 3168 for Prism Press, Melbourne (1974).

9. Sussman, Sidney: Nowakowski, Oskar, and Constantino, John J., "Experiences with Sodium Nitrite: Unpredictable Corrosion Inhibitor", Industrial and Engineering Chemistry, April, 1959.

10. Uhr, Daniel R., Jr., "Organic Acid Pickling of Steels", Paper Presented at a Meeting of the South Atlantic Section, National Association of Corrosion Engineers, November 14, 1978, Jacksonville, Florida.

11. Wackenhuth, Erwin; Lamb, L.W.; Engle, J.P., "Use and Disposal of Boiler Cleaning Solvent", Power Engineering.

ANNEX A

COMPARISON OF SURFACE PROFILE OF CITRIC ACID AND ABRASIVE BLAST PREPARED PANELS

ANNEX A

Due to the importance placed on the relationship between paint performance and film thickness, an attempt was made during the course of this investigation to control dry film thicknesses applied over steel panels designated for comparative tests. With extremely precise spray application procedures, the final measured dry film thicknesses of the paint applied to the citric acid prepared panels were still different from the dry film thicknesses of paint applied to the abrasive blast prepared panels. A speculation regarding the cause of this phenomenon concerned possible differences in the profile of the differently prepared steel test panels prior to paint application. Therefore, an investigation was made into the possible relationship between surface profile and film thickness measurements.

The first step was to measure and record the profiles of both the citric acid cleaned steel and abrasive blast cleaned steel using numerous measurement techniques (no uniformly accepted method exists). The results of these measurements are listed in Table VIII. The abrasive blast technique used to initially descale all panels and to reblast those panels designated to be final abrasive blast panels consisted of compressed air blasting. The inlet air pressure was 100psi with sufficient volume to create little or no pressure drop at the nozzle (verified with needle gauge). The nozzle type was a 1/4″ venturi. The abrasive blast media used was a coal slag abrasive with an average Knoop Hardness Number of 600 with a 200 gram load. This hardness is roughly equivalent to hardened tool steel (63.8 HRC) which is 740 at the same load. The screen analysis was:

SCREEN	PERCENT RETAINED
U.S. No. 12	1.7%
U.S. No. 16	18.2%
U.S. No. 20	22.1%
U.S. No. 40	49.7%
U.S. No. 50	9.3%

As stated in the body of this report, all descaled panels were allowed to rust for ten weeks in a marine environment prior to recleaning for painting. The citric acid profile was created using the process defined in Section 2.4.1 of this report.

The differences in measured profiles between abrasive blast cleaned steel and citric acid cleaned steel varied widely depending on the measurement technique used. The "Gardner Model 123" difference was 1.44 roils; the "Press-O-Film" difference was 0.38 roils and the "Mico-Test" gauge difference was 0.24 roils. The toolmakers microscope measurement actually had a negative difference using the citric acid measurement as the subtrahend in each case.

An analysis of the difference in film thicknesses revealed that on an average basis, the primers applied to the abrasive blasted panels had a higher measured thickness than the same generic primer applied to citric acid cleaned panels. This mean difference equaled 0.19 roils. Upon closer examination, it was found that in a few isolated cases a negative difference was observed. Identification of the primers associated with this variance from the norm revealed that most were generic primers known for substrate wetability, e.g. polyamines. Mr. John Keane in Ref. 4 has reported on this phenomenon. He discussed the point that some paints "flood" the valleys between the peaks of surface topography whereas thixotropic materials follow the contour of the surface. He further states that the paint flow into the profile is dependent upon the theological properties of the paint.

By deleting those materials with known ability to wet the substrate from the analysis, the statistical difference in measured film thickness was 0.31 roils. Note that this closely approximates the measured difference in profile as measured using "Micro-Test" magnetic film thickness gauge, i.e. 0.24 roils.

The above analysis supports four conclusions:

1. The same generic primers within this test series applied to both the abrasive blasted and citric acid prepared steel panels have the same relative film thicknesses within a specific generic set. Therefore, in this **particular test** series, comparative primer performance is not a function of profile, but is a function of surface compatibility.
2. In most cases tested, the primer applied to a given substrate followed the topography of the substrate and did not flow out leaving exposed profile.
3. Magnetic film thickness gauges should be calibrated in accordance with Steel Structures Painting Council Standard SSPC-PAZ-73T which takes into account measurable profile.
4. A technique or procedure could be developed to test the wetability of a coating based on the phenomenon discussed within this annex.

TABLE VIII: Comparison of Profile Measurements of Citric Acid and Abrasive Blast Using Various Instruments

	KEANE-TATOR SURFACE PROFILE COMPARATOR	GARDNER MODEL 123 PROFILE COMPARATOR	PRESS-O-FILM	TOOLMAKERS MICROSCOPE	MICRO TEST FILM THICKNESS GAUGE
ABRASIVE BLAST USING COAL SLAG ABRASIVE	3S70				
MEAN	3.15 mils	3.88 mils	3.12 mils	2.68 mils	0.69 mils
MEDIAN	3.04 mils	3.9 mils	3.1 mils	2.4 mils	0.65 mils
RANGE	1.73-5.03 mils	2.1-4.9 mils	2.9-3.4 mils	1.0-5.1 mils	0.3-1.4 mils
CITRIC ACID (FIRST DESCALED WITH COAL SLAG ABRASIVE AND THEN ALLOWED TO RUST PRIOR TO CLEANING)	2S70				
MEAN	1.92 mils	2.44 mils	2.74 mils	2.78 mils	0.45 mils
MEDIAN	1.89 mils	2.4 mils	2.8 mils	2.6 mils	0.4 mils
RANGE	0.94-2.99 mils	1.2-3.7 mils	2.6-2.8 mils	0.9-5.6 mils	0.2-0.8 mils
	NOTE: This instrument is a visual subjective comparator		NOTE: This process utilizes a replication film and a dial indicator.		Magnetic Gauge calibrated to zero of polished surface and then checked for accuracy against the NBS certified Standards for Coating Thickness

ANNEX B
POWER TOOL CLEANING PROCEDURE

ANNEX B

Extract of Catalog of Existing Small Tools for Surface Preparation and Support Equipment for Blasters and Painters.

(2.3. 2.1 Power Tool Cleaning Procedure for Erection Joints

The following procedure can be used on vertical, downhand, overhead and structural fillet welds. All welds should first be scaled.

Weld Bead

1. Welds were needle gunned to remove residual slag and deep rust in weld pores. A Cleco-Dresser needle scaler, Model B1-B, with round-nosed standard needles was used.
2. Welds were then buffed with a cup wire brush. A Cleco-Dresser vertical grinder, Model 15V-45 was used with 3.5″ cup wire brush (Osborn knot-type, .020″ wire, Model 4220). A Cleco-Dresser horizontal grinder, Model 15 GEL-180, equipped with a Black and Decker 4“ radial-type brush (Catalog No. 23201) can be useful “in cleaning the edges of welds, corners and other hard-to-reach areas.

   On weld undercuts and restricted areas, a die grinder (Cleco-Dresser, Model 11-GLF-250, 25,000 rpm) equipped with an Osborn 2“ ring lock radial wire brush with .014“ wire (Model 2080-S-38) proved effective.

Flat Areas and Feather Edging

The removal of rust, burned and smoked paint, and feather edging of paint was accomplished with a vertical grinder (Cleco-Dresser, Model 15-V-45) equipped with a No. 16 grit resin disc pad (Marvel No. C-2 H-D).)

ANNEX C

PAINT SYSTEM/SUPPLIER DECODING PROCEDURE

ANNEX C

System Codes can be translated as follows. The first alpha designation denotes supplier. The second alpha designation denotes surface preparation technique, i.e. “B” for Abrasive Blast and “C” for Citric Acid Cleaned. The last numeric notation is only a sequence number and has no further intelligence. The following is a list of suppliers and associated codes:

SUPPLIER	CODE
Ameron	A
Byco	B
Carboline	
Devoe	D AND L
Imperial	E
International	F
Mobil	G
Mobile	H
Napko	I
Porter	J

For example code AB1 can be translated as an Ameron System applied over an Abrasive Blasted substrate. The number 1 denotes the first system of the Ameron series.

SHIP PRODUC

FACILITIES IN

OUTFITTING AND

INDUSTRIAL ENGINEERING F

SHIPBUILDING S

DESIGN/PRODUCT

COMPUTER AIDS

SURFACE PREPARATIC

FLEXIBLE A

TECHNOLO

EDUCATION

WEL